Southwest Fisheries Science Center
Administrative Report H-96-09

WPACFIN Island Data Assessment (WIDA) of American Samoa Small Boat-Based Fishery Survey, 1985-93 and Shoreline Fishery Survey, 1990-93

Bert S. Kikkawa

Honolulu Laboratory, Southwest Fisheries Science Center
National Marine Fisheries Service, NOAA
2570 Dole Street, Honolulu, Hawaii 96822-2396

October 1996

NOT FOR PUBLICATION

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ABSTRACT

From 1985, the Government of American Samoa, Department of Marine and Wildlife Resources (DMWR) has monitored the territory's small-boat fishery. This offshore survey consisted of tallying daily fishing activity and interviewing fishermen returning to one of the five major launching sites on the island of Tutuila. In 1990, DMWR restarted the shoreline creel survey to monitor reef resources on the island of Tutuila. The shoreline survey included roving participation counts and concurrent interviews of the fishermen from 22 villages along the south shore of Tutuila. Both surveys were conducted weekly on 2 randomly selected weekdays (WD) and 1 weekend or holiday (WE/H). In 1992, Western Pacific Fisheries Information Network (WPACFIN) initiated the Western Pacific Fishery Information Network Island Data Assessment (WIDA) Project to evaluate the survey design and the data collected from their surveys.

From 1985 to 1993, catch and effort data from the boat-based fishery were evaluated. The data were stratified by trolling, bottomfishing, combined trolling and bottomfishing, spearfishing methods, day types (WD and WE/H), and calendar quarters. Through the years, the number of daily fishing trips has declined. Daily trolling trips averaged 1.77 WD and 2.04 WE/H with corresponding catch rates of 3.6 and 3.7 kg/gear-h. Following the bottomfishing peaks in 1985 and 1986, effort fell and remained at a very low level. Bottomfishing trips averaged 0.63 and 0.59 per day for WD and WE/H with an average catch rate of 2.33 kg/gear-h. Combined trolling and bottomfishing method trips averaged 0.46 WD and 0.56 WE/H per day with 2.6 kg/gear-h overall catch rate. Spearfishing trips averaged 0.55 and 0.64 per day for WD and WE/H, respectively. Overall mean catch rate was 2.49 kg/gear-h.

Guidelines for the number of sampling days required to estimate mean daily within each quarter were presented for the four fishing methods. The number of survey days needed to estimate mean daily trolling trips and catch rates at the 20% coefficient of variation (CV) level ranged from 6-14 and 3-18 for WD and WE/H, respectively. Mean daily bottomfishing effort and catch rates can be estimated with 14-38 WD and 1-9 WE/H survey days. For both combined and spearfishing methods, 25-41 survey days for both day types were needed to estimate mean daily effort. Combined method catch rates were less variable through the years and consequently, only 1-8 sampling days per quarter were needed. However, for estimating mean daily spearfishing catch rates, 2-19 survey days were required.

Predictive length-weight regressions were determined for eight bottomfish species of which two displayed allometric growth. Shallow bottomfishes were numerically predominant. Surplus production models were applied to both trolling and bottomfishing catch and effort data. Estimated trolling Maximum Sustainable Yield (MSY) was 122 t, 21 t above the peak landings in 1986. Estimated bottomfishing MSY was 25.5 t, 3.2 t below the peak bottomfish landings in 1986.

The shoreline fishery was monitored weekly on 2 randomly selected WD and 1 WE/H, with a surveyor counting and interviewing fishermen while driving along the coastal highway. Catch rates and effort were evaluated for the five major shoreline fishing methods. Of the three line fishing methods, rod-and-reel catch rates were highest with an overall mean of 1.17 kg/gear-h. Due to the high variance in the catch rates within quarters, 5-29 survey days were needed per quarter to estimate the mean at 20% CV. Bamboo pole fishing recorded the lowest mean catch rates (0.27 kg/gear-h) that required 1-18 survey days per quarter. Mean handline catch rates were higher (0.8 kg/gear-h), though the number of survey days remained about the same. Fishing activity was highest for reef gleaning, and catch rates ranged from 0.45-3.63 kg/gear-h. About 1-8 days were needed to estimate a quarterly mean catch rate. Spearfishing catch rates were 200% higher at night with a mean of 3.34 kg/gear-h and 1-6 survey days to estimate quarterly means.

INTRODUCTION

With the passage of the Magnuson Fishery Conservation and Management Act of 1976, the National Marine Fisheries Service (NMFS), an agency of the U.S. Department of Commerce, was designated to provide the best fishery information available to the newly formed Western Pacific Regional Fishery Management Council. In 1981, the Western Pacific Fisheries Information Network (WPACFIN) was created under the auspices of the NMFS to implement, systematize, and maintain fisheries information necessary for the development of fishery management plans for waters within the U.S. Exclusive Economic Zone. The American Samoa Department of Marine and Wildlife Resources (DMWR) is one of the participating agencies in WPACFIN.[1]

In 1971, the DMWR (then the Office of Marine Resources (OMR)) first began monitoring the fisheries of American Samoa by collecting catch reports from both foreign longline fleet and local subsistence, and commercial fishermen. Because reporting was strictly voluntary for the local fishermen, the catch reports from subsistence fishermen were soon found to be unreliable. As a result, the department redirected most of their efforts to the domestic offshore commercial fishery and the foreign fleet. Later in April 1975, returning fishermen were interviewed to get more accurate catch and effort information; however, because of budgetary cutbacks the department reverted to examining and analyzing voluntary catch reports from the fishermen in October 1976.[2] The DMWR, in 1979, began to actively monitor the domestic commercial fishing fleet by interviewing returning fishermen at five major launching sites around the island of Tutuila. At this time, the commercial fleet was comprised primarily of *alias* (wooden catamarans) and manta cats (7.92-8.84 m (26-29 ft) long), outboard-powered (aluminum or fiberglass catamarans) (Fig. 1), and a larger longline vessel. By 1984, the fleet had more than doubled in size, increasing from 18 to 46 vessels (Hamm et al., 1988). Although the survey was highly successful in tracking the commercial fishery, the monitoring system bypassed both recreational and subsistence fisheries. Beginning in October 1985, the DMWR initiated a new survey program to monitor all of the boat-based fisheries on the island of Tutuila. The creel survey was patterned after a successful creel survey in Guam. The new survey offered a comprehensive coverage of the

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[1]Participating agencies in WPACFIN include the American Samoa Department of Marine and Wildlife Resources; the Commonwealth of Northern Mariana Islands (CNMI), Division of Fish and Wildlife; the Guam Division of Aquatic and Wildlife Resources (DAWR); Guam Department of Commerce; State of Hawaii, Division of Aquatic Resources; the NMFS, Honolulu Laboratory and Pacific Area Office; and the Western Pacific Region Fishery Management Council.

[2]Statistical Analysis of American Samoa's Fisheries in the Annual Report by Government of American Samoa Office of Marine Resources, Project No. 4-36-D-2, Period: July 1, 1976-September 30, 1977. Submitted by Richard C. Wass and Henry S. Sesepasara; Dec. 27, 1977, 6 pp.

island's fishing activities and more accurate estimates of catch and effort. However, the new survey was not implemented on the Manu'a Islands. Because of its small fleet, individual vessels could be easily tracked on a daily basis.

Traditionally, early Samoans spent much of their time fishing on the reef flats or near the reef edge. This practice offered a means of providing food for the family and a source of recreation. Customarily, only men fished and the women and children would wade on the reef at low tide with sharp sticks and knives to gather small fishes and invertebrates. Women were not permitted, by Samoan custom, to fish outside the reef or from canoes (Buck, 1930). Today, with increasing technology and westernization of the islands, traditional methods have changed. The DMWR began monitoring the shoreline fishery fronting 22 villages along the southern shore of Tutuila Island in 1990. The survey was similar to earlier work by R. Wass (1980) who measured the fishing catch and effort of subsistence and recreational fishermen on and shortly beyond the fringing reefs. And like his study, all boat-based fishing effort was excluded.

The WPACFIN, in 1992, initiated the WPACFIN Island Data Assessment (WIDA) Project to evaluate creel survey designs and data from the islands of Guam, American Samoa and CNMI. The project initially evaluated the Guam DAWR offshore creel survey in 1994 where guidelines were established for determining the number of sampling days needed to estimate mean daily catch rates and fishing activity (Kikkawa, 1994). Subsequently, in the summer of 1994, WPACFIN/WIDA and the American Samoa DMWR staff began preliminary evaluation of the current offshore and shoreline creel surveys. The offshore fishery study included four major fishing methods: trolling, bottomfishing, combined trolling and bottomfishing, and spearfishing. The shoreline survey study involved rod-and-reel fishing, handline and bamboo pole fishing, reef gleaning, and spearfishing. Biological data were evaluated for stock assessment and fishery management purposes. This manuscript presents the WIDA Project's appraisal of the WPACFIN program's fishery data collection system in American Samoa during 1985-93.

Study Site

The U.S. Territory of American Samoa consists of a chain of seven islands located approximately at latitude 14°S and longitude 170°W (Fig. 2). The main island of Tutuila contains about 95% of the total resident population of 44,580. Aunu'u, a smaller island, 1.4 km off the southeastern tip of Tutuila has a population of 463. The Manu'a Islands (Ofu, Olesaga, and Ta'u) are 105 km east of Tutuila with 1,714 inhabitants. Swain's Island has 16 residents and is located 350 km to the north of Tutuila. And Rose Atoll, 290 km to the east, is uninhabited (U.S. Census, 1990). Tutuila is approximately 32 km long and 4 km wide and almost centrally divided by Pago Pago Harbor, a deep natural bay. Two-thirds of the island is bounded by a narrow fringing reef with a single, well-developed lagoon. About 33% of the island's population reside in the Pago Pago Harbor area.

Mean daily temperature at American Samoa remains nearly constant throughout the year, fluctuating between 25.6-27°C, November-April being the hottest months of the year.

Mean monthly rainfall ranges from 15.2-38.1 cm and is heaviest from October to May. Average monthly windspeed ranges from 13-23.1 kph and is highest during June-November.

Offshore Fishery

Prior to October 1985, the Government of American Samoa DMWR (then OMR) closely monitored the domestic commercial fisheries. Estimates of commercial landings were obtained by intercepting and interviewing fishermen upon their return to one of the five major launching sites on the island. Catches then accounted for 98% of total landings (Aitaoto, 1985). DMWR, in October 1985, launched a new program to monitor all components of the boat-based fishing activity to provide more comprehensive island-wide estimates of effort and landings. The new American Samoa Offshore Expansion System (ASOES) was modeled after the Guam offshore survey design and expansion system (Hamm et al., 1988). The ASOES was implemented only on the island of Tutuila.

Catamaran vessels of manta cats (aluminum) and *alias* (wooden), skiffs ranging from 3.66-4.57 m (12-15 ft) long, and three to four larger charter fishing type vessels of 13.41 m (44 ft) length make up the fishing fleet. The DMWR conducts annual island-wide vessel inventories to determine the size of the fishing fleet and to identify the boats that are actively fishing. During the last 3 years of the study, 1991-93, the fleet size averaged 92 vessels of which 57% were actively fishing.

The offshore or boat-based creel survey monitors five major launching sites around the island. On a sampling day, the surveyor tallies the number of fishing trips out at each port and interviews returning fishermen for catch and effort information. Of the five stations, the floating docks of Fagatogo/Pago Pago where 87% of the daily activity occurs is the most active. The floating docks have a carrying capacity of 40-50 vessels and are currently the berthing site for 27 vessels. Located close to local marketplaces, the ice machine, and within the sheltered confines of the bay, it is an ideal harbor. On the outer edge of Pago Pago Bay is the village of Faga'aluu with 1,006 inhabitants, and is the site for two actively fishing vessels. To the north and over the steep mountains is the village of Fagasa and a harbor with one boat in its protected bay. Leone is the most populous village with more than 3,000 people and the berthing site of only one active fishing boat. Currently, Utulei is the only one of the five designated sampling sites without any active fishing vessel (Fig. 3).

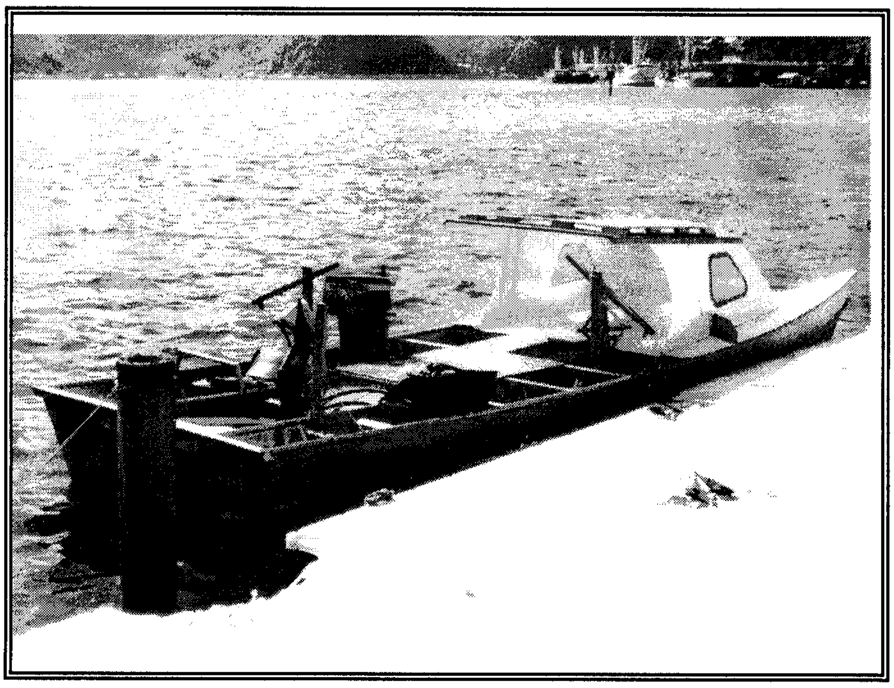

Figure 1.--Samoan catamaran (manta cat) fishing vessel with aluminum hulls. The vessel is equipped with outboard engines, and two hand reels for trolling and bottomfishing.

Through the years, much of the fishing has occurred to the south of the island (Fig. 2), just beyond the edge of the fringing reef and on the banks about 18.5-64.8 km east of Tutuila. Catches from distant offshore banks (Northeast, East, 2%, and Southeast Banks) were usually larger and frequented more often by the seasoned fishermen. Tutuila-based vessels typically fished with a three-man crew for approximately 12.5 hours, while Manu'a-based vessels fished with a four-man crew for an average of 5 hours. Offshore fishing methods included bottomfishing, trolling, spearfishing, netting, longlining, and *atule* fishing.

Inshore Fishery

In 1990, the DMWR began monitoring the shoreline fishery to evaluate the impact on reefs fronting 22 shoreline villages (Fig. 4), encompassing Pago Pago Harbor and beyond, from Lauli'ituai to Nu'uuli by subsistence and recreational fishermen. The study is similar to an earlier work by the OMR, in 1977 to 1980, to monitor catch and effort exerted by subsistence and recreational fishermen and assess the economic, recreational, and cultural values of the shoreline fishery (Wass, 1980). The estimated harvest[3] of the shoreline resources was approximately 20% of the offshore fishery annual estimated landings in 1991 (Hamm et al., 1994; Ponwith, 1991). Monitored shoreline activities included rod-and-reel fishing, handline fishing, bamboo pole fishing, reef gleaning, spearfishing, gillnetting, throw netting, mining, and swimming.

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[3]Annual shoreline landings were adjusted for highly seasonal *atule* catches.

METHODS

Offshore Fishery

The offshore creel survey was conducted with the surveyor driving to and inspecting each of the five major launching sites and villages on the island: Faga'aluu, Utulei, Fagatogo/Pago Pago, Fagasa, and Leone (Fig. 3). At each port, the surveyor counts the number of missing boats by tallying empty berths and trailers. He then intercepts and interviews as many returning fishermen for catch and effort information. Gathered information included date, day type, time, boat name, method of fishing, total catch weight, number of fishermen, number of gear, area fished, and species composition (Fig. 4). Individual fish lengths and weights were collected whenever possible. Currently, the offshore fishery centers on the docks at Fagatogo/Pago Pago where more than 87% of the active fishing fleet berth. Surveys were conducted weekly on 2 randomly selected WD and 1 WE/H between 0500-2100. WIDA evaluation of the American Samoa offshore survey centered on data from the island of Tutuila.

Island-Wide Fishing Effort Estimates

Estimates of daily island-wide fishing activity for the four major fishing methods were determined by extrapolation of the five major sites. The survey information was expanded both temporally and spatially with daily proportional adjustment factors, $p1$ and $p2$. Temporal expansion factor, $p1$, was the proportion of daily activity that occurred within the survey time frame. $P1$ was estimated by compiling informal observations and other anecdotal information from the villagers about night fishing activities for that day. The spatial expansion factor, $p2$, was the proportion of the offshore fishing fleet originating from one of the five major launching sites. Estimates of $p2$ were made by garnering information about the fishery through the periodic island-wide vessel inventories, anecdotal information from fishermen, and monitored activity other than at the survey sites. In this study, monthly averages of p values were used to measure the expansion of daily effort. Basically, island-wide fishing effort was estimated by dividing the number of trips from the five major sites by $p1$ and $p2$.

Besides logging fishing activities, the surveyor attempted to intercept and interview as many returning vessels as possible on the sampling day at each of the five major sites, even though complete coverage of the day's activity was not always possible. Information gathered from the interviews included catch, effort, fishing method, species composition, and size frequencies. In the WIDA analysis, uninterviewed vessels and trips originating outside the survey area were proportionately assigned fishing methods. Fishing methods were proportionally allocated by the ratio of number of fishing trips for each method to the total monthly interviews by each day type as a p factor and expressed as:

$$p_{factor_i} = \frac{\sum_{j=1}^{n} e_{ij}}{\sum_{i=1}^{m}\sum_{j=1}^{n} e_{ij}} , \tag{1}$$

where e_{ij} is effort in the number of daily fishing trips on the *j*th sampling day for the *i*th method. Fishermen were assumed to be randomly interviewed and that ratio of fishing methods from the survey was similar to the island-wide fishing activities. In other words, if half of the sampled trips were trolling trips, it is also assumed that half of all the fishing trips for the day were trolling.

In the WIDA evaluation of the offshore fishery the data were stratified by day type, the four major fishing methods (trolling, bottomfishing, combined trolling and bottomfishing, and spearfishing), and into quarters. Although the data were collected on a weekly schedule, pooling by quarters was necessary to increase the number of observations for better estimates of variance within each stratum. Incidental and highly seasonal fishing methods such as *atule* and longlining were not included in the analysis.

Mean quarterly catch rate, R' were determined with a ratio estimator, r' and defined as:

$$\bar{R}' \simeq \bar{r}' = \frac{\sum_{h=1}^{m_j}\sum_{i=1}^{n_h} C_{hi}}{\sum_{h=1}^{m_j}\sum_{i=1}^{n_h} f_{hi}} , \tag{2}$$

where C_{hi} is the sum of catches over the *i*th interviews and *h*th survey day and similarly, f_{hi} is the sum of the fishing effort over the *i*th interviews on the *h*th survey day for the quarter. The ratio estimator is a self-weighting mean estimator. However, the variance must be calculated with a special formula (Mendenhall et al., 1971) and algebraically expressed as:

$$V(\bar{r}) = \left(\frac{N-n}{N\,n}\right)\left(\frac{1}{\mu_f^2}\right)\frac{\sum_{i=1}^{n}(c_{hi} - r f_{hi})^2}{n-1} , \tag{3}$$

where N is total number of trips in a season, n, the number of interviewed trips in a season, and r, the mean seasonal catch rate for each day type. Because the population mean effort, μ_f is unknown, $\overline{f}^2$ can be substituted to approximate μ_f^2 in the equation (Mendenhall et al., 1971). Quarterly catch rates were calculated by day types, and the quarterly variance-mean relationships were determined by regressing log variance against mean catch rate for each of the fishing methods.

Monthly distributions of catch and effort (fishing activity) means and variances and daily number of interviews were examined by day type to better understand the trends in the boat-based fishery. Temporal patterns of the p values and boat registration numbers were also examined to detect potential survey bias in the coverage of the fishery. Specific length and weight information from the commonly caught species was reviewed and fitted with a multiplicative regression model for some of the species. Gonadal information from the market sampling program for sexual maturity studies was inadequate for any kind of analysis.

Bottomfishing and trolling catch and effort data were evaluated for stock assessment purposes by applying them to surplus production models. To further improve the relationship between fishing effort and abundance, trolling and bottomfishing methods were stratified into offshore-bank and nearshore fisheries. Both the Schaefer (1954) and Fox (1970) equilibrium models were used to estimate yields from trolling and bottomfishing methods. The Schaefer model expressed CPUE as a linear function of effort, $Y(I)/f(I) = a + b\, f(I)$ if $f(I) \leq -a/b$. The slope, b, must be negative if (Y/f) decreases for increasing effort. The modified Schaefer or Fox model is the logarithm of the CPUE, (Y/f) as a linear function of effort, such as ln $(Y(I)/f(I)) = c + d(I)$.

Size frequency information on the more commonly caught bottomfishes was used in progressive modal analysis for estimating the von Bertalanffy growth constant, K and asymptotic weight, W_{∞}. Because the data collected, at any one time, were insufficient for monthly or seasonal evaluation size frequencies were pooled over the year. The components of frequency distributions were separated and identified with a distribution mixture model developed by MacDonald and Pitcher (1979). The identifiable modes were assumed to be cohorts and were later integrated into the modal progression analysis.

Sample Size Determination-Offshore Fishery

The offshore fishery was monitored under a very rigorous sampling schedule of 2 WD and 1 WE/H a week; however, due to the low number of daily fishing trips for each of the fishing methods, the data were pooled into quarters. These periods were chosen as 3 consecutive monthly intervals starting from January (Jan-Mar, Apr-Jun, Jul-Sep, Oct-Dec). Historically, the number of daily fishing trips on weekends and holidays was consistently higher than those on the weekday, although not significantly. Because of the invariably higher daily trip rates, counts were stratified by day type. In this study, only the four major fishing methods of trolling, bottomfishing, combined trolling and bottomfishing, and spearfishing were evaluated.

The precision levels of 10, 20, and 30% CV of the means were used as guidelines for determining the number of survey days for estimating mean daily participation and catch rates. Precision levels of 10 and 30% were selected as the upper and lower bounds to the current survey sampling standard of 20%. Creel survey data from 1984 to 1993 were used to establish sampling guidelines in the number of survey days for each of the four major fishing methods by quarter and type days. The number of days (n) was determined by the following formula as:

$$n = \frac{s^2}{CV^2 \, \bar{x}^2} , \tag{4}$$

where CV is the desired level of precision and expressed as a proportion, s^2 is the population variance of the variable to measured, and $\bar{x}$ is the estimated mean (Elliot, 1971; Cochran, 1977). The population variance was replaced by an empirically determined function of the mean as described below; thereafter, variance can be predicted from a calculated or estimated mean. Quarterly means from the past 3 years were used to predict the next year's quarterly means. In addition to providing discrete estimates on the number of sampling days, a dynamic approach of the model was presented in a graphical format for each major fishing method by quarter and type day.

The variance-mean relationships were determined by regressing the log variance within each quarter against quarterly means for each of the fishing methods and day types. However, because the distributions of daily fishing trip counts were abnormal or skewed, both the negative binomial and the Poisson models were used to describe the distribution.

Shoreline Survey

The primary objectives of the shoreline creel survey were to assess two important components of the fishery: (1) daily average fishing effort, and (2) catch rate by fishing method for each village within the survey area. The study area included a 16-km stretch of shoreline on the southern side of Tutuila Island which included 22 villages and three habitat types. The survey centered on Pago Pago Harbor, extending to the villages to the east and west of the harbor (Fig. 5). There were 11 fishing methods (rod-and-reel, handline, bamboo pole fishing, reef gleaning, spearfishing, throw netting, gillnetting, other methods, *palolo* fishing, swimming, and sand mining) in the shoreline fishery. However, for the WIDA analysis only five major fishing methods were studied: rod-and-reel, handline, bamboo pole, reef gleaning, and spearfishing.

Shoreline creel surveys were conducted 3 days per week, 2 WD and 1 WE/H. The days were selected quasi-randomly, but with some minor adjustments on the selection of days to maximize the survey team's effort and efficiency, and to include effects of lunar tidal and weather conditions. Unlike the offshore fishery, the shoreline fishery was monitored for a 24-hour time span in order to assess both day (0600-1800) and night (1800-0600) components of the fishery; however, the fishery was surveyed for 8 hours within each period. The WE began on Friday evening at 1800 and concluded on Saturday midnight instead of from Saturday to Sunday, as in an earlier study by Wass (1980). Holidays were similar to that of the WD such that a day started and ended at midnight. Sundays were considered as a WD.

For many of the villages, fishing remained prohibited for all or part of Sunday, thus, fishing effort remained at low levels which was similar to that of a WD effort rate (Wass, 1980).

Assessment of the shoreline fishing effort was made by the surveyor while he drove along the coastal roadway fronting the villages, stopping periodically at designated observation points to tally fishermen and identify their fishing methods. Typically, within the 8-hour survey period, four runs were conducted or about one run every 2 hours. One of the requirements to accurately determine fishing effort was that the surveyor complete the track in about an hour and not to exceed 1.5 hours. Daily fishing effort was determined by multiplying the average number of fishermen per run by the hours in the time period for each of the methods. This can be mathematically expressed as:

$$f_i = \frac{\sum_{n=1}^{j} f_{ij}}{j} \cdot 8 , \tag{5}$$

where f_i is the estimated fishing effort for the ith method, f_{ij} is the count of fishermen in the ith method during the jth survey run, and j is the number of runs made during that time period. For example, if the mean number of reef gleaners per run was 2.5 fishermen, the estimated gleaning effort would be 20 fishermen hours for the day.

The second element of the survey involved estimating mean daily catch and effort for each of the major fishing methods. Like the offshore fishery survey, interviews of shoreline fishermen were conducted essentially for gathering catch and effort and other biological and social information. Interviews of fishermen were typically made after each participation run, however, for the rare fishing methods such as gillnetting, the surveyors were encouraged to seek and interview fishermen whenever possible. This included gathering information on non-survey days or interrupting a count to get the needed catch and effort data. Interviews were considered only if fishing effort exceeded 30 minutes. Information included the date, type of day (WD or WE/H), village where the interview had taken place, status of fishing (completed or in progress), time of interview, number of gear units, size of the fishing party, and the count and weight of each species or species group. Catch rates were determined with the ratio estimator (equation 2) and variance estimated with appropriate formula (equation 3).

In the WIDA study of the shoreline fishery creel survey, the data were pooled over villages into habitat types that were categorized with respect to Pago Pago Harbor (Table 1). Areas on the outer fringes of the study site and beyond the confines of the harbor were considered exposed reef. Regions between the harbor and exposed reef habitats were identified as the outer harbor habitat. The harbor is characterized by a fairly protected region with shallow muddy flats at the mouth and adjoining deep pier areas. The outer harbor areas can be found along the outward fringes of the harbor and, although somewhat protected within the confines of the bay, these areas were distinguished with numerous tracts of extended coral reefs. The exposed reefs were located on the fringes of the sample area and distinguished by the fact that parts of the reefs were exposed at low tide. The outer harbor and exposed reef habitats, and reef area from the shoreline to the breakers or shelf edge were similar in size at 0.992 km^2 (0.383 mi^2) and 1.008 km^2 (0.389 mi^2), respectively. The area of the inner harbor was about 0.056 km^2 (0.022 mi^2) with a total study area of about 2.05571 km^2 (0.79371 mi^2)[4].

The shoreline fishery was also monitored on a demanding schedule of 2 WD and 1 WE/H a week. In the analysis, the data were stratified by day and night time periods and pooled into quarters (Jan-Mar, Apr-Jun, Jul-Sep, Oct-Dec) and villages into the three major habitat types. This was necessary because of the low daily fishing rates for most of the methods. Through the years, daily fishing effort was consistently higher on WE/H than on WD except for reef gleaning. Although the differences were not significant, effort was stratified by day types because of the invariably higher WE/H activity rates.

The biological data on the shoreline fishery were insufficient for any conclusive analysis and are not included in this report.

Sample Size Determination--Shoreline Fishery

As with the offshore fishery, establishing guidelines for determining the number of survey days for estimating catch, effort, and daily fishing activity rate was one of the primary objectives of the WIDA shoreline fishery study. These guidelines were developed on the creel survey data from 1990 to 1993 for each major fishing method. A similar procedure was followed in determining the number of survey days needed for estimating mean daily effort and catch rates at the precision levels of 10, 20, and 30% CV. The means from the previous 3 years were used to approximate the next year's mean daily catch and activity rates.

RESULTS

Offshore Fishery

One of the underlying assumptions in the survey design of the ASOES is that interviews of fishermen are taken randomly. The annual frequency distributions of landings and number of trips by vessel registration numbers indicated the presence of a few highliners in the fishery. However, during the first 3 years of the study and in 1993, fishermen were interviewed randomly and not selective toward the highliners. By contrast, the surveyors appeared to have favored specific vessels from 1988 to 1993 as indicated in a median runs test for randomness.

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[4]Reef habitat area was determined through a canned conversion algorithm which was part of the SigmaScan software developed by Jandel Scientific (1992), 259 Kerner Boulevard, San Rafael, CA 94901.

Through the years, fishing patterns have been evident for trolling fishermen such that they leave early in the morning and return to port between 1700-2000. On the other hand, bottomfishermen start in the late afternoon, fish throughout the night, and return the next morning between 0700-1100. Interview results of fishermen with combined trolling and bottomfishing methods reported that catches were highest at 0700-1100 and 2000. Spearfishermen typically landed their catches between 0600-0800.

An estimated 92-97% of the Tutuila fishing fleet launched out of the five survey sites on the island during 1985-93. And because of the fishery monitoring schedule of 0500-2100, only 76-81% of the day's fishing activity could be covered. The number of expanded daily trips for WD and WE/H ranged from 0-9.27 and 0-12.33, respectively. Except for bottomfishing, the number of daily trips on WE/H was higher. Although the variability in the number of trips between days was relatively high, overall declining trends through the years in the number of daily fishing trips were evident for each of the fishing methods:

Trolling	-	β_{WD} = -6.393E-4 (Pr >0.000), α_{WD} = 2.793 $\beta_{WE/H}$ = -7.894E-4 (Pr >0.000), $\alpha_{WE/H}$ = 3.316
Bottomfishing	-	β_{WD} = -0.2832 (Pr >0.0082), α_{WD} = 2.2188 $\beta_{WE/H}$ = -0.1649 (Pr >0.0200), $\alpha_{WE/H}$ = 1.4425
Mixed method	-	β_{WD} = -0.0652 (Pr >0.0116), α_{WD} = 0.6839 $\beta_{WE/H}$ = -0.0883 (Pr >0.0059), $\alpha_{WE/H}$ = 0.8790
Spearfishing	-	β_{WD} = -0.1271 (Pr >0.0026), α_{WD} = 1.0610 $\beta_{WE/H}$ = -0.08124 (Pr >0.2708), $\alpha_{WE/H}$ = 0.8997,

where the y intercepts α, and slope β, are presented below for each method and type of day.

During the 8 years of the study, the monthly mean number of expanded daily trolling trips ranged from 0-4.25 WD and 0-7.71 WE/H, with no detectable trend (Fig. 6). Mean daily WE/H effort was consistently higher than WD although the difference was not statistically significant in a two-sample comparison ($\bar{x}_{WD}$ = 1.77, n=846; $\bar{x}_{WE/H}$ = 2.04, n = 392, KSd = 0.0731, Pr >0.12; where KSd is the Kolmogorov-Smirnov maximum deviation value and Pr is the level of significance). WD trolling trips averaged about 7.9 hours and ranged between 4.9-12.4 hours. Trolling trips on WE/H averaged length were similar at 8.0 hours and varied between 5-16.2 hours. WE/H fishermen averaged 3.15 lines per trip which was about a 10% increase over WD trollers.

Bottomfishing effort was highest during the last quarter of 1985 and the first quarter of 1986, at a time when bottomfish were extensively exported and sold on the Hawaiian-fresh fish market. From 1985 to 1993, the monthly mean number of daily bottomfishing trips ranged from 0-4.24 and 0-3.53 for WD and WE/H with overall daily averages of 0.58 WD and 0.54 WE/H. The difference in the number of fishing trips between type days was again not significant in a Kolmogorov-Smirnov two-sample comparison (n_{WD} = 685, $n_{WE/H}$ = 246, *KSd* = 0.0431, Pr >0.20). Bottomfishermen normally fished for an average of 13.7 hours on WD with a range of 5.5-24.7 hours per trip. WE/H bottomfishing trips were shorter with an average of 12.5 hours and ranged from 4.5-24.0 hour per trip. The average number of lines fished per trip was 2.5 and 2.6 for WD and WE/H, respectively.

With combined trolling and bottomfishing method, the daily number of WD and WE/H trips ranged from 0-1.48 and 0-1.95, with an overall mean daily of 0.44 WD and 0.54 WE/H trips. Fishing effort between the 2-day types was not significantly different (n_{WD} = 528, $n_{WE/H}$ = 205, *KSd* = 0.0637, Pr >0.20). Combined method fishermen typically fished longer than straight bottomfishermen or trollers. On the WD, the length of the fishing trips ranged from 6.8-31.5 hours and averaged 16.6 hours. WE/H trips averaged 15.5 hours of fishing and varied between 6-24.3 hours.

During the study period, spearfishing effort had been declining steadily from the high of two trips per day during the summer of 1987-88 to near zero at the end of the period. Daily spearfishing averaged 0.54 (WD) and 0.64 (WE/H) trips per day. Fishing effort on WE/H was significantly higher (n_{WD} = 415, $n_{WE/H}$ = 102, *KSd* = 0.17487, Pr >0.017). Spearfishing trips averaged 8.8 hours with 4.8 gears per trip for WD. WE/H trip effort averaged 9.1 hours with 4.7 gears per trip.

Another purpose of the study included the evaluation of the creel survey data for stock assessment. Catch and effort data from 1985 to 1993 were examined and stratified into fishing areas of nearshore and offshore banks before applying it to the various available fishery stock production models. Trolling catch rates annually averaged 3.63 and 3.72 kg/gear-h (8.0 and 8.2 lb/gear-h) and fluctuated between 2.72 and 4.99 kg/gear-h (6 and 11 lb/gear-h) for both nearshore and offshore bank fishing. Offshore catch rates were highest in 1989 with a daily mean of 7.03 kg/gear-h (15.5 lb/gear-h). Nearshore catch rates were highest in 1988 with a daily mean of 3.22 kg/gear-h (7.1 lb/gear-h). Mean bottomfishing catch rates were higher on offshore bank (2.81 kg/gear-h (6.2 lb/gear-h)) than nearshore (1.86 kg/gear-h (4.1 lb/gear-h)).

Mean annual catch rates for mixed fishing methods were very similar (2.68 and 2.63 kg/gear-h (5.9 and 5.8 lb/gear-h)) from both nearshore and offshore areas. Catch per gear-h ranged from 1.68-3.90 kg/gear-h (3.7-8.6 lb/gear-h). All boat-based spearfishing activity was directed to the nearshore areas and the annual mean catch rates varied from 1.68-3.31 kg/gear-h (3.7-7.3 lb/gear-h). The overall mean catch rate was 2.49 kg/gear-h (5.5 lb/gear-h).

Trolling and bottomfishing catch and effort data were applied to surplus production models. Because fishermen who fished the surrounding banks were more experienced and had vessels that were capable of distant water fishing (D. Itano, pers. commun.), stratification by offshore bank and nearshore areas was necessary because of differences in the effort and catchability of the target species. Estimates of yield were determined under equilibrium conditions for both nearshore and offshore bank fishing.

Preliminary estimates of trolling maximum sustainable yield (MSY) from offshore banks were 27.2 t (30 T) from 9,000 line-h and 29.5 t (32.5 T) from 12,000 line-h effort from the Schaefer (1954) and Fox (1970) models, respectively. Estimates of MSY for bottomfishing on nearshore fishing grounds were 19.1 t (21 T) with 11,000 line-h and 19.1 t (21 T) with 14,000 line-h of effort for each respective model. Results from both nearshore trolling and offshore bank bottomfishing were inconclusive with either model. Trolling catches in 1988 from both nearshore and offshore bank combined peaked at 91 t (100.4 T) with 20,600 line-h effort. Peak bottomfish landings in 1986 totaled 28.7 t (31.7 T) from 7,497 line-h.

Biological data collected from 1985 to 1993 (included a short-term market sampling program) amounted to 487 individual fishes that represented nine species. Each fish was measured for length and weight, however, only five species had >10 observations (Table 2). Shallow-water bottomfishes were predominant, and the *savane* or blue-lined snapper, *Lutjanus kasmira*, accounted for 64% of collected information although catches of the blue-lined snapper contributed to about 2% of the total landings on Tutuila. *L. kasmira* can be found in shallow lagoons and as deep as 265 m on the outer reef slope. During the day, they form large aggregations and disperse at night to feed on benthic crustaceans and fishes (Myers, 1989). The size frequency data on the *savane* included only 2 years which were inadequate for any time series analysis.

The most comprehensive weight frequency information were collected on the *palu malau*, or *Etelis carbunculus*. Sample sizes ranged from 0.23-15.9 kg (0.5-35 lb) with the highest catches in the 0.23-2.27 kg (0.5-5.0 lb) range. A total of 150 weight measurements were collected from 1986 to 1991 which was inadequate for any kind of size distribution analysis. *E. carbunculus* is a commercially valuable bottomfish and can be found in waters ranging from 60-250 m deep (Myers, 1989).

Sample Size Guidelines--Fishing Activity and Catch Rate Estimates

Sampling guidelines and the number of days to estimate mean daily activity and catch rates were developed on the distributions of historical means and variances. Relationships were determined by fishing method and stratified by calendar quarter and day type. These relationships were used as a predictor of variance from an estimated mean. For each of the fishing methods, the means of daily fishing activity rates were positively related to its variance, such that the slopes were >1 for each method within each quarter and day type. Typically, positive slopes indicated that the distributions of the daily counts on fishing trips were clustered or negatively and binomially distributed. Variance of a negative binomial distribution, however, must be determined by the following formula:

$$s^2 = \bar{A} + \frac{\bar{A}^2}{k}, \tag{6}$$

where s^2 is the variance, $\bar{A}$ is the mean and k is the exponent in the negative binomial series.

The inverse of *k* can be used to describe the clustering or excess variance of the individual observations in a population (Elliot, 1971). Albeit, because of the low daily fishing activity rates a Poisson distribution model resulted in a more parsimonious estimate of the variance. The Poisson distribution is described as a mathematical model usually associated with distribution of counts, where $\mu = \sigma^2$ (Sokal and Rohlf, 1969). As a result of the lower variances from the Poisson model, the number of survey sampling days for estimating the means was reduced. At the 20% CV level, the number of days ranged from 18-129 and from 6-49 for the negative binomial and Poisson models, respectively (Table 3). Besides providing discrete estimates of the number of days, the WIDA study also presented, graphically, a dynamic model for determining the sample size. Figure 7 was developed on a Poisson model with the estimated mean daily participation on abscissa and the predicted number of days needed to estimate daily activity on the ordinate for each corresponding CV isopleths (10, 20, and 30%).

Survey days for estimating trolling catch rates ranged from 3-5 WD and from 5-18 WE/H (Figs. 8-11). Because bottomfishing catch rates were less variable, fewer sampling days were necessary (1-5 and 2-9 days for WD and WE/H, respectively) (Figs. 12-15). For combined method trips, the number of days for estimating means ranged from 5-8 WD and 1-8 WE/H (Figs. 16-19). During the last 3 years of the study period, spearfishing dropped and remained at very low levels such that the number of days to estimate mean catch rates for WD and WE/H ranged from 3-9 and 2-19 days (Figs. 20-23). The number of survey sampling days to estimate mean catch rates at the three CV levels is presented in Table 4 for each of the methods, type day, and quarter.

Inshore Fishery Survey

Evaluation of the current inshore survey included fishery data collected from July, 1990 to December, 1993. The information was stratified by day and night periods, type day (WD and WE/H), five major fishing methods (rod-and-reel, bamboo pole, handline, gleaning and spearfishing), three habitat types (inner harbor, outer harbor and exposed reef), and calendar quarters. Daily fishing effort was determined by counting fishermen as the surveyor drove from one end of the survey area to the opposite end, with frequent stops at each village, to count fishermen and identify the fishing method. Typically, the starting point of the track was village 1, but in 1993 the starting points alternated between villages 1 and 22. It took an average of 42 minutes to complete a run.

Day fishing activity rates were higher than night, and during the study period an increasing trend was apparent that runs with counts of >100 fishermen were becoming more frequent. As a result, counts per day of <25 fishermen that occurred about 90% of the time in 1990 have dropped to 77% by 1993. During the same period, the number of runs with counts of >50 fishermen increased from 0-5.5% for WD and 0-34% for WE/H. Fewer night fishermen were observed with less than a hundred individuals counted per survey run. Fishermen counts of >50 have decreased for both WD and WE/H from 15-0% and 6.25-0%.

Guidelines on the number of sampling days to estimate mean daily fishing effort were developed on the distributions of means and variances and their relationships. In order to improve the estimates of the means and variances it was necessary to pool the information into quarters, combining villages into three habitat types, and limiting fishing methods to rod-and-reel, bamboo pole, handline, spearfishing, and reef gleaning. The variances were found to be positively related to the means for each of the strata and increased with increasing means. This positive relationship usually indicates that the distribution for the daily fishing effort is of a negative binomial distribution.

The predicted number of survey days for estimating rod-and-reel fishing effort during the day ranged from 9-74 (WD) and from 7-35 (WE/H) at the 20% CV precision level. The lower variance in the night fishing activities resulted in a narrower range, from 1-27 and 1-13 days for WD and WE/H, respectively. Night fishing was limited to the outer harbor and exposed reef areas (Tables 5 and 6).

Like rod-and-reel, handline fishing was not observed in the inner harbor area. The range of survey days per quarter for daytime fishing was similar for both WD (7-21) and WE/H (4-29). In contrast, as a result of the lower variance of night handline fishing effort, the number of survey days for both day types was very low, 1-4 days.

During the day, fishing with bamboo poles typically occurs on the exposed reef and outer harbor areas, but occurs only on the outer harbor areas at night. To estimate mean quarterly pole fishing effort at the 20% CV precision level, 6-24 (WD) and 3-36 (WE/H) survey days were necessary. At night, less days (3-7) were required for each day type for bamboo pole fishing at the outer harbor area.

It is clear that because the inner harbor areas were without any significant and productive reefs, gleaning was not observed there. The survey days for each quarter ranged from 2-25 and 2-22 for WD and WE/H for day effort. At night, 2-36 WD and 1-10 WE/H days in each quarter were necessary for a 20% CV precision in the estimates.

Spearfishing was observed in all three habitats within the survey area. The amount of survey days needed to estimate mean daily spearfishing effort at the 20% CV level in an exposed reef habitat extended from 5-11 WD and 5-14 WE/H. Throughout the study, fishing effort within the harbor area was most variable. This high variability resulted in an increase of monitoring days to 8-18 WD and 5-74 WE/H. Fishing effort within the inner harbor was similar between day types so that the number of survey days to estimate mean daily effort ranged from 12-26 for both day types. Except for the fourth quarter, night spearfishing was, overall, less variable with only 2-19 days of monitoring necessary and 67 days for the fourth quarter.

Catch and effort data were collected by method, village, type day, and time period which for this study were pooled into quarters and the three habitat types. Monthly catch rate means and variances were examined; however, only rod-and-reel catch and effort data that were collected during the day allowed for predicting the number of survey sampling days.

Information collected during the night on all fishing methods was too sparse or the distribution of variances did not allow for any reasonable prediction in the number of survey sampling days. Mean catch rates from the last 3 years were again used to determine the number of days needed to estimate mean catch rates by the habitat and day types.

Mean quarterly rod-and-reel catch rates ranged from 0.18 to 1.91 kg/gear-h (0.4-4.2 lb/gear-h) with an overall mean of 1.07 kg/gear-h (2.35 lb/gear-h) during the day. WE/H catch rates were lower with a mean 0.69 kg/gear-h (1.53 lb/gear-h). Catch rates on WE/H were higher with a mean of 1.27 kg/gear-h (2.80 lb/gear-h). The number of days in a quarter needed to estimate mean rod-and-reel catch rate at the 20% CV in the outer harbor area, during daylight hours, ranged from 1-2 days for WD and WE/H combined (Table 7).

Much of the handline catch and effort information was gathered from fishermen in harbor areas during the day and from outer harbor areas at night. Mean catch rates were 1.07 and 0.64 kg/gear-h (2.22 and 1.41 lb/gear-h) for day and night, respectively. Mean catch rates from bamboo pole fishermen were much lower at 0.20 and 0.33 kg/gear-h (0.44 and 0.73 lb/gear-h) for both day and night fishing. Pole fishing was centered at the inner and outer harbor areas during daylight hours. Interviews of these fishermen were few and intermittent throughout the year. Number of days to estimate bamboo pole fishing catch rates at 20% CV could not be determined.

Reef gleaning had the highest activity rate and centered on the outer harbor and exposed reef habitats. Catch rates for exposed reefs ranged from 0.45-3.63 kg/gear-h (1-8 lb/gear-h) and for outer harbor areas 0.45-0.91 kg/gear-h (1-2 lb/gear-h). Variance of catch rates was such that the number of survey days to estimate mean catch rates for both areas and type days was inconclusive. At night, gleaning activity was largely reduced to a catch rate of about 1.36 kg/gear-h (3 lb/gear-h).

Quarterly spearfishing catch rates from exposed reef and outer harbor areas ranged from 0.45-3.17 kg/gear-h (1-7 lb/gear-h) during the day and 3.17 kg/gear-h (7 lb/gear-h) at night. Mean WE/H catch rate of 1.26 kg/gear-h (2.78 lb/gear-h) was >77% greater than that of WD (0.71 kg/gear-h or 1.56 lb/gear-h). Average spearfishing catch rate at night was 3.34 kg/gear-h (7.36 lb/gear-h) which was about 200% higher than the day.

DISCUSSION

This study focused on a creel survey system which was designed to monitor catch and effort from the boat-based fishery. Through the years, nearly all of the information was gathered from the *alias*-based fishery. This is in contrast to the annual vessel inventories that have shown both *alias* and skiffs were actively fishing. Currently is it unknown if there is a bias toward *alia* fishermen and if the skiffs are used for fishing. Because the offshore survey was centered on the five major launching sites around the island where over 90% of the monitoring occurred, possible explanations for favoring the catamaran type vessels are: (1) they are moored and easier to monitor, and (2) the present survey sampling effort could be a carryover from the pre-ASOES years at a time when DMWR was monitoring the commercial fleet which was the *alia*-type vessels.

Daily island-wide fishing activity rates were determined by expanding the survey data both spatially and temporally. The temporal expansion factor, $p1$, was the proportion of the daily fishing activity occurring within the survey period between 0500-2100. The value of $p1$ is highly dependent upon the environmental conditions which can change significantly between sampling days, day types, and fishing methods. During the 12 years of the study, the temporal expansion factor appeared constant at times and impervious to the vagaries of the fishery. The study recommends that $p1$ should reflect the conditions of the fishery. In a mathematical simulation experiment, the variances of fishing activities that were expanded by a constant of 0.8 were compared to activities that were assumed to be representative of the fishery. This was decided by expanding the creel survey information with random p values between 0.8 and 1.0. The range of $p1$ was used to simulate the changes in the fishery conditions. The results showed that variances of fishing activity were overestimated by at least 26% and 24% for WD and WE/H when the constant p value was below the mean of 0.9. In contrast, when $p1$ was above that mean and at a higher level of 0.97, variances were underestimated by 16% for WD and 11% for WE/H. As a consequence, there would be oversampling when the $p1$ underestimates and undersampling when $p1$ overestimates the temporal adjustment factor.

From 1985 to 1992, the mean number of daily fishing trips has been declining for both WD (β_{WD} = -0.000347, (Pr >0.0046), α_{WD} = 37.6207 and WE/H ($\beta_{WE/H}$ = -0.002802 (Pr >0.1318), $\alpha_{WE/H}$ = 34.6989). Offshore fishery interview coverage in the later years of the study period also dropped, with only 25% of the returning fishermen interviewed. Assuming that monitoring effort remains constant, the surveyor's coverage of the fleet should increase as fishing activity declines. The low interview rate could be a result of the surveyors covering a large sampling area and failing to intercept the smaller number of returning fishing boats. Currently, more than 80% of the *alia* fleet launches out of Fagatogo/Pago Pago docks, and although monitoring of the offshore fishing activity has been very effective in the past with a roving creel survey design, it is clear that more effort at the Fagatogo/Pago Pago docks must be directed toward increasing the number of interviews. The study suggests that the surveyors also focus their monitoring effort on when fishermen would most likely return to port. Historically, bottomfishermen and spearfishermen were most likely to return during the morning hours and trollers, in the late afternoon.

In predicting the number of survey days required to estimate mean daily activity, quarterly mean and variance relationships were examined and found to be positively related. Although the relationship suggests that fishing activities were clustered, there was no discrete seasonality in the fishery except for bottomfishing (F. Aitaoto, pers. commun.). However, because of the low fishing activity rates a Poisson model was used instead, which resulted in lower variance estimates. As a consequence, fewer sampling days were necessary at the three precision levels.

Catch rates on WD were higher than WE/H, and the difference could be explained by the fact that the part-time commercial and more experienced fishermen generally do most of the fishing during the week. Also, most of the vessels in American Samoa are without the aid of any electronic gear, i.e., depth sounder or G.P.S., and typically locate fishing grounds through landmark sightings. The more seasoned fishermen were able to consistently locate the more productive offshore fishing grounds. In contrast, recreational fishermen usually fish on the weekends and holidays and are inclined to have lower catch rates.

After the peak bottomfishing period in the mid-1980s, the number of fishing trips to offshore banks has dropped. With the collapse of the export market (Hawaiian fresh fish market) and a local preference for smaller fish (0.5-2.0 kg), the demand for deep-water bottomfish remained at low levels. Spearfishing effort also declined significantly, along with the number of spearfishermen interviews. This was the result of some commercial spearfishermen leaving the fishery and others switching their method of operation from boat to land-based operations (F. Aitaoto and A. Kingsolving, pers. commun.).

One of the key objectives of this study was to determine the number of survey days for estimating mean daily catch rates for each of the fishing methods. Of the four major fishing methods, trolling and spearfishing catch rates were the most variable within the quarter and required more survey sampling days. The variability in the trolling catch rates could be the result of changes in the fishing practices through the years, i.e., targeting wahoo and mahimahi for export and, possibly, the effects of the recent vertical longlining success for large yellowfin, bigeye, and albacore tunas in Western Samoa (Itano, 1991).

The WIDA project also focused on the utility of the creel survey data for fishery management purposes. The project tried the simplest stock assessment model--the surplus production model that utilizes catch and effort data to estimate biomass yield. Although the model was intended for a single species, both bottomfish- and troll-caught fishes were aggregated and treated as bottomfish and pelagic unit stocks. Because a fisherman in a tropical multispecies fishery is capable of catching a variety of species that differ in behavior, spatial and temporal distribution, and market prices, catch rates may not be reliable estimates of species abundance. Also, in recent times the use of production models has declined in favor of age-structured models. Production models use a single number to describe population biomass and ignore the complexities of age structure and spatial distribution, and are often used in fisheries where catch-at-age data are difficult to obtain. Since biomass is rarely measured directly, most applications of the models use an index of abundance catch-per-unit-effort (CPUE), and estimation procedures are complex and highly model dependent. Therefore, it becomes necessary to consider changes in fishing practices and techniques, and abundance and distribution of the fish such that fishing effort can cause catch rates to be a biased estimator of abundance (Hilborn, 1979).

Production modeling under equilibrium conditions failed to estimate MSY for both inshore trolling and offshore bottomfishing. Preliminary estimates of trolling MSY from offshore banks averaged 28 t. Because the models failed to predict nearshore MSY, offshore MSY was extended proportionately by the landings from each stratum (nearshore and offshore banks). Catches from offshore banks accounted for 25% of the total landings, thus, total adjusted trolling MSY would be about 112 t. In 1988, landings of troll-caught fish peaked at 81 t, about 72% of the MSY. In contrast, adjusted bottomfish MSY of 76.4 MT was 11% below peak landings in 1986. Hilborn and Walters (1992) emphasized that equilibrium models frequently overestimate surplus production and optimum effort when applied to data gathered during stock decline (e.g., during fishery development) despite the fact that stocks are never in equilibrium. Although the use of these two static production models is often discouraged, they can offer gross estimates of the potential fishery yields. The reasons for the failure of the models could be the resulting divergence between fishing effort and stock abundance. Fishermen frequently troll around the fish aggregating devices (FADs), and because these devices concentrate on fishes, catch rates can no longer be good indicators of abundance.

Of all the biological data that were collected, size frequency information was studied as an alternative to ageing hard body parts because fewer technical skills are required, no elaborate equipment is needed, and the data can be easily collected. However, these studies can be time-consuming, and a minimal number of observations in a decided time period are required. Unfortunately, size frequency data on *E. carbunculus,* which were the most numerous, were inadequate for modal analysis. An annual average of 25 observations was collected on *E. carbunculus*, which was insufficient for any definition and subsequent annual mode tracking.

Inshore Fishery

Evaluation of the American Samoa inshore fishery included about 3.5 years of data. During this short period, there have been several modifications to the sampling design and because of these changes, variance estimates might have been upwardly biased and not indicative of the fishery. The study focused on the five dominant fishing methods. Information that was partitioned by villages was pooled into habitat type and temporally stratified into calendar quarters. The pooling of the data was necessary to increase sample size and to provide a better relationship of catch and effort to the fishing area. Stratification by habitat would be appropriate because correlation of catch and effort to the habitat of the target species would be higher than to villages. This might not be true for some of the more isolated villages where the *matai* (chief) or *tautai* (village master fisherman) manages the resources fronting his village.

Inshore fishing activities were monitored through four hourly participation runs during each stratum (day and night). A run took an average of 42 minutes to complete, and because of the 18-minute difference from the time coefficient (60 minutes), the expansion program underestimated the inshore effort by about 30%. The study recommends one of the following corrective measures: (1) change the time constant to 42 minutes to reflect the prevailing mean, (2) allow for a dynamic time coefficient in the expansion program so that the actual elapsed time of each run can be inputted into the program, or (3) create a timetable for the designated points along the route to keep the surveyor closer to the 60-minute schedule.

The inshore activity counts were negatively and binomially distributed, typifying the clustering nature of the inshore fishery. Line fishing methods were often clumped during seasonal fishing. Gleaning and spearfishing were most likely to be aggregated on good weather days. Through the years, daily daylight fishing activity has been comparatively higher than night fishing. Reasons were not clear for the increasing daylight fishing activity rates and contrasting dropping nightly fishing activities. Possible explanations for changes in daylight fishing activities would be because of survey technique improvements that have been made through the years and familiarization of the daylight inshore fishery. The declining night fishing can be attributed to ineffective monitoring on some of the fishing methods in addition to the closure of some night fishing spots such as the harbor area.

The variance of fishing activity was high for each method, which could be the result of changes in the survey design and monitoring methods. In turn, days to estimate the mean hourly participation for each of the five major fishing methods were also elevated. Unlike monitoring fishing activities, catch and effort information was gathered opportunistically which could introduce some bias into the data. In the past, the surveyors were partial toward line fishermen rather than any other fishermen in their interviews (S. Saucerman, pers. commun.).

SUMMARY AND RECOMMENDATIONS

Offshore Fishery

Results of the American Samoa small-boat based fishery study have shown that fishing effort for all methods has declined through the years. Although the weekly sampling schedule remained at 2 WD and 1 WE/H, fishermen interview rates have also dropped and as a result, a reduction in the precision of estimating daily fishing effort has occurred. Because the fishery is currently monitored on a very rigorous sampling schedule, the WIDA Project recommends that the survey team increase the interview coverage of the fishery before making changes to the sampling schedule. This can easily be accomplished by improving coverage at the Fagatogo/Pago Pago docks where 87% of fleets berth.

As a result of the high variability of fishing activity between days, the predicted number of sampling days required to estimate mean daily activity was also elevated. A factor contributing to a higher variance is the imprecise estimates of *p* values. The project recommends that more accurate *p* values are needed for each survey day.

Although length and weight data are considered to be the basis of fishery research and management, only four species included such data in any appreciable amount. DMWR should exert more effort in collecting additional length and weight information directed at the designated management species. This can be carried out at the docks at the time of landing or through a market sampling program.

For many of the primary fishery management species caught around American Samoa, size and age at first maturity and spawning season are yet to be determined. Knowing growth rates or the age and size of a fish at maturity will help us better understand the dynamics of the fishery. Age determination can be accomplished in the following ways: (1) empirically, with tag and recapture methods, (2) statistically, with length-frequency distributions, and (3) anatomically, with ageing of body parts. Based on the available resources, WIDA recommends using the statistical approach of ageing fishes for some of the short-lived species. Although catches include a large number of species with few specimens of a single species in a tropical multispecies fishery, collecting enough size-frequency data for any one species for modal analysis in a time series or length-weight analysis is often very difficult. This is especially true for many of the bottomfish species. Under the proper conditions, size information from the creel survey must be supplemented with a market sampling program. However, care must be taken to collect unbiased samples with the exclusion of imported fish. A market sampling program can also be used to obtain the needed biological samples for maturity studies. For the long-lived fishes, ageing of body parts is suggested, although a considerable amount of time and effort is needed for the study. Recent studies have shown that for long-lived fishes, length is not indicative of age (Williams et al., 1995).

For maturity and spawning seasonality studies, it would be prudent to begin with two or three of the most common and commercially valuable species, i.e., *Lethrinids* or snappers. Seasonality can be determined by observing the changes in the gonadosomatic index over time. Size, at first maturity, can be determined by examining gonadal development relative to size during the spawning season.

Shoreline Fishery

From the start of the shoreline survey by DMWR, a few years ago, it was unclear how the department would manage the reef resources. Unlike some of the isolated villages where the shoreline resources fronting the village have been traditionally under the control of the *matai*, villages in the study site appeared to be not as closely managed. Like the offshore fishery monitoring system, much of the fundamental data for fishery research and management are not available, i.e., length and weight data, size-frequency information, size at maturity, and spawning season. As with the offshore survey system, it is necessary that the inshore survey team initiate a program for collecting the needed information. However, the surveyor must first be able to identify catches to the species level.

RECOMMENDATION SUMMARY

Through the years, the offshore daily activity rates have remained low but for some of the methods, variances remained high. As a consequence, the study recommends that the surveyors (1) improve the interview rates by directing their efforts to the Pago Pago floating docks, and (2) provide for a more accurate p values in the expansion program. Moreover, the study highly recommends that (1) the team maximize its effort in getting the fundamental fishery information on the primary management species, such as size at maturity, growth rates, lengths and weights, and spawning seasons, and (2) the surveyors (both inshore and offshore) identify catches to the species.

ACKNOWLEDGMENTS

I thank the staff of American Samoa Department of Marine and Wildlife Resources, and especially Fini Aitaoto for their help and cooperation in this study. Also, thanks go to David Hamm for sharing with me his invaluable experience and knowledge of the fishery. Sincere thanks to Dr. Samuel Pooley for his editorial and scientific comments in making this paper possible and, also, to Judy Kendig for her editorial assistance. Review comments and advice from Dr. Jeffrey Polovina, Dr. Peter Craig, Alan Kingsolving, Alan Everson, and Susan Saucerman are also appreciated.

CITATIONS

Aitaoto, F.
1985. Domestic commercial fishery in American Samoa, October 1, 1984-September 30, 1985. Annual Report. Government of American Samoa, Office of Marine Resources. Pago Pago, American Samoa 96799.

Buck, Sir Peter H.
1930. Samoan Material Culture. B. P. Bishop Museum Bull. 75, 724 p.

Elliot, J. M.
1971. Some methods for the statistical analysis of samples of benthic invertebrates. Freshwater Biological Association Scientific Publication 25:157 p.

Fox, W. W., Jr.
1970. An exponential surplus-yield model for optimizing exploited fish populations. Trans. Am. Fish. Soc. 99:80-8.

Hamm, D. C., and M. M. Quach.
1988. Fishery statistics of the Western Pacific. Volume III. Territory of American Samoa (1985-86), Commonwealth of the Northern Mariana Islands (1985-86), Territory of Guam (1985-86) and State of Hawaii (1985-86). Southwest Fish. Cent. Honolulu Lab., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96822-2396. Southwest Fish. Cent. Admin. Rep. H-88-04.

Hamm, D. C., F. Dowdell, and M. M. Quach.
1994. Fishery statistics of the Western Pacific. Volume IX. Territory of American Samoa (1992), Commonwealth of the Northern Mariana Islands (1992), Territory of Guam (1992) and State of Hawaii (1992). Southwest Fish. Sci. Cent. Honolulu Lab., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96822-2396. Southwest Fish. Sci. Cent. Admin. Rep. H-94-02.

Hilborn, R.
1979. Comparison of fisheries control systems that utilize catch and effort data. J. Fish. Res. Bd. Can. 36:1477-1489.

Hilborn, R., and C. J. Walters.
1992. Quantitative Fisheries Stock Assessment: choice, dynamics and uncertainty. Chapman and Hall, 29 West 35 St., NY, NY 10001, 570 p.

Kikkawa, B. S.
1994. Western Pacific fishery information network island data assessment (WIDA) project: small-boat fishery survey in Guam, 1980-91. Southwest Fish. Sci. Cent. Honolulu Lab., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96822-2396. Southwest Fish. Sci. Cent. Admin. Rep. H-94-03.

MacDonald, P. D., and T. J. Pitcher.
1979. Age groups from size-frequency data: A versatile and efficient method of analyzing distributions mixture. J. Fish. Res. Board Can. 36:987-1001.

Mendenhall, W., L. Ott, and R. Scheaffer.
1971. Elementary survey sampling. Wadsworth Publishing Company, Inc., Belmont, CA 94002.

Myers, R. F.
1989. Micronesian reef fishes: A practical guide to the identification of the coral reef fishes of the tropical central and western Pacific. Coral Graphics, P.O. Box 21153, Guam Main Facility, Barrigada, Territory of Guam 96921, 298 p.

Ponwith, Bonnie J.
1991. The shoreline fishery of American Samoa: a 12-year comparison. Department of Marine and Wildlife Resources Biological Report Series, No. 22, 51 pp.

Sokal, R. R., and F. J. Rohlf.
1969. Biometry-The principles and practice of statistics in biological research. W. H. Freeman and Company, San Francisco, CA, 776 p.

Wass, R. C.
1980. The shoreline fishery of American Samoa-Past and Present. Dept. Mar. and Wildlife Res., Biol. Rept. Ser. No 1. Bureau of Census, 1992. 1990 Census of population and housing; Social, economic, and housing characteristics; American Samoa. U.S. Dep. of Comm., Economic and Statistics Admin., Bureau of Census, 1990-CPH-6-AS. U.S. Government Printing Office, Wash. DC 20402, p. 302 with appendices.

Williams, David McB., Stephen J. Newman, Michael Cappo, and Peter J. Doherty.
1995. Recent advances in the aging of coral reef fishes. Background paper for Joint FFA/SPC Workshop on the Management of South Pacific Inshore Fisheries, Noumea, New Caledonia, 26 June-7 July 1995, 4 pp.

Table 1.--Villages and the three habitat types in study site for American Samoa shoreline survey on the island of Tutuila during 1990-93.

Village	Type of habitat
Lauli'ituai	outer reef
Lauli'ifou	outer reef
Onososopo	outer harbor
Aua	outer harbor
Lepua	outer harbor
Leloaloa	outer harbor
Atu'u	inner harbor
Anua	inner harbor
Satala	inner harbor
Pago Pago	inner harbor
Malaloa	inner harbor
Fagatogo	outer harbor
Utulei	outer harbor
Faga'alu	outer harbor
Fatumafuti	outer harbor
Matu'u	outer reef
Uasa'aiga	outer reef
Faganeanea	outer reef
Avau	outer reef
Oneoneloa	outer reef
Nu'uuli	outer reef

Table 2.--Length-weight regression for fish caught around American Samoa during 1985-93. Each species are sample size (*N*), fork length (FL), size range of fitted data, goodness of fit ratio (r^2), and estimates of intercept and estimates of intercept and slope with their respective standard errors (SE) for the model log (WT) = a + b' log (FL). Weight is in pounds and fork length in centimeters.

Scientific name	*N*	FL size range (cm)	r^2 (%)	Intercept (SE)	Slope (SE)
Acanthurus lineatus	4	7.5-19.9	99	- 3.41(0.093)	2.97(0.039)
Acanthurus triostegus	46	8.0-12.8	94	- 3.35(0.254)	2.93(0.109)
Aprion virescens	7	50.5-68.5	88	-10.69(2.742)	4.03(0.678)
Ctenochaetus striatus	64	9.9-21.0	95	- 3.87(0.246)	3.09(0.097)
Lethrinus rubrioperculatus	92	27.0-32.5	94	- 3.55(0.245)	2.88(0.074)
Lethrinus amboinenis	6	28.3-44.5	99	- 4.09(0.410)	3.01(0.114)
Lutjanus boutton	14	18.5-27.0	98	- 3.21(0.345)	2.78(0.111)
Lutjanus kasmira	307	15.0-32.6	86	- 3.63(0.210)	2.90(0.067)

Table 3.--Number of days to estimate mean daily offshore participation on American Samoa at the 10, 20, and 30% CV levels during 1991-93. Both the negative binomial (*a*) and (*b*) distributions were used to estimate variance of the means. TRL = trolling, BTM = bottomfishing, CMB = combined methods, and SPR = spearfishing.

				CV level					
				10%		20%		30%	
Type day	Method	Qtr	Daily mean	*a*	*b*	*a*	*b*	*a*	*b*
WD	TRL	1	2.53	114	40	29	10	13	4
WD	TRL	2	1.85	122	54	30	14	14	6
WD	TRL	3	2.21	90	45	22	11	10	5
WD	TRL	4	1.78	144	56	36	14	16	6
WD	BTM	1	0.39	144	56	36	14	16	6
WD	BTM	2	0.41	144	56	36	14	16	6
WD	BTM	3	0.65	207	154	52	38	23	17
WD	BTM	4	0.61	228	164	57	41	25	18
WD	CMB	1	0.15	228	164	57	41	25	18
WD	CMB	2	0.11	228	164	57	41	25	18
WD	CMB	3	0.04	228	164	57	41	25	18
WD	CMB	4	0.17	228	164	57	41	25	18
WD	SPR	1	0.01	228	164	57	41	25	18
WD	SPR	2	0.03	228	164	57	41	25	18
WD	SPR	3	0.02	228	164	57	41	25	18
WD	SPR	4	0.01	228	164	57	41	25	18
WE/H	TRL	1	3.86	71	26	18	6	8	3
WE/H	TRL	2	3.61	102	28	26	7	11	3
WE/H	TRL	3	2.45	152	41	38	10	17	5
WE/H	TRL	4	2.38	516	42	129	11	57	5
WE/H	BTM	1	0.37	516	42	129	11	57	5
WE/H	BTM	2	0.53	264	189	66	47	29	21
WE/H	BTM	3	0.51	226	196	56	49	25	22
WE/H	BTM	4	0.45	226	196	56	49	25	22
WE/H	CMB	1	0.01	226	196	56	49	25	22
WE/H	CMB	2	0.11	226	196	56	49	25	22
WE/H	CMB	3	0.11	226	196	56	49	25	22
WE/H	CMB	4	0.17	226	196	56	49	25	22
WE/H	SPR	1	0.01	226	196	56	49	25	22
WE/H	SPR	2	0.01	226	196	56	49	25	22
WE/H	SPR	3	0.01	226	196	56	49	25	22
WE/H	SPR	4	0.01	226	196	56	49	25	22

Table 4.--Number of days required to estimate mean daily offshore catch rates in American Samoa at the 10, 20, and 30% CV levels for the four major fishing methods. Mean daily catch rate was estimated from the 1991-93 offshore survey interview data. TRL = trolling, BTM = bottomfishing, CMB = combined methods, and SPR = spearfishing.

Type day	Method	Qtr	Daily mean	CV level		
				10%	20%	30%
WD	TRL	1	8.70	13	3	1
WD	TRL	2	3.87	20	5	2
WD	TRL	3	6.11	15	4	2
WD	TRL	4	6.68	14	3	2
WE/H	TRL	1	6.14	21	5	2
WE/H	TRL	2	2.32	71	18	8
WE/H	TRL	3	*	*	*	*
WE/H	TRL	4	*	*	*	*
WD	BTM	1	7.28	19	5	2
WD	BTM	2	4.64	20	5	2
WD	BTM	3	4.24	19	5	2
WD	BTM	4	13.78	4	1	1
WE/H	BTM	1	6.42	14	3	2
WE/H	BTM	2	4.03	34	9	4
WE/H	BTM	3	5.15	20	5	2
WE/H	BTM	4	7.19	8	2	1
WD	CMB	1	6.90	27	7	3
WD	CMB	2	3.17	19	5	2
WD	CMB	3	4.08	25	6	3
WD	CMB	4	5.15	34	8	4
WE/H	CMB	1	6.31	22	6	2
WE/H	CMB	2	3.17	19	5	2
WE/H	CMB	3	5.85	5	1	1
WE/H	CMB	4	*	*	*	*
WD	SPR	1	9.29	14	3	2
WD	SPR	2	3.14	35	9	4
WD	SPR	3	5.16	20	5	2
WD	SPR	4	4.37	14	4	2
WE/H	SPR	1	6.98	13	3	1
WE/H	SPR	2	3.74	77	19	9
WE/H	SPR	3	5.90	7	2	1
WE/H	SPR	4	*	*	*	*

*No interviews were made during this period.

Table 5.--Number of days required to estimate mean daily shoreline participation during the day on American Samoa from the 10, 20, and 30% CV levels during 1991-93. Negative binomial model was used to estimate variance of the means. ER = exposed reef, OH = outer harbor, IH = inner harbor, RR = rod and reel, BP = bamboo pole, HL = handline, RG = reef gleaning, and SP = spearfishing.

Type day	Habitat	Method	Qtr	Daily mean	CV level 10%	CV level 20%	CV level 30%
WD	ER	RR	1	9.33	42	11	5
WD	ER	RR	2	8.03	39	10	4
WD	ER	RR	3	6.56	35	9	4
WD	ER	RR	4	5.08	53	13	6
WD	ER	HL	1	8.60	36	9	4
WD	ER	HL	2	9.71	58	14	6
WD	ER	HL	3	6.41	56	14	6
WD	ER	HL	4	3.00	56	14	6
WD	ER	BP	1	9.40	70	18	8
WD	ER	BP	2	9.00	28	7	3
WD	ER	BP	3	5.49	97	24	11
WD	ER	BP	4	6.00	29	7	3
WD	ER	RG	1	27.16	92	23	10
WD	ER	RG	2	10.38	42	11	5
WD	ER	RG	3	20.83	62	16	7
WD	ER	RG	4	16.56	91	23	10
WD	ER	SP	1	10.70	26	6	3
WD	ER	SP	2	12.67	42	11	5
WD	ER	SP	3	10.93	19	5	2
WD	ER	SP	4	9.38	37	9	4
WD	OH	RR	1	13.45	97	24	11
WD	OH	RR	2	33.74	151	38	17
WD	OH	RR	3	10.47	42	11	5
WD	OH	RR	4	8.49	79	20	9
WD	OH	HL	1	8.64	26	7	3
WD	OH	HL	2	9.86	26	7	3
WD	OH	HL	3	10.28	43	11	5
WD	OH	HL	4	7.32	85	21	9
WD	OH	BP	1	7.54	34	9	4
WD	OH	BP	2	18.86	23	6	3
WD	OH	BP	3	5.86	22	6	2
WD	OH	RG	1	24.34	98	25	11
WD	OH	RG	2	12.52	9	2	1
WD	OH	SP	4	11.98	51	13	6

Table 5.--Continued.

Type day	Habitat	Method	Qtr	Daily mean	CV level 10%	CV level 20%	CV level 30%
WD	IH	RR	1	10.75	45	11	5
WD	IH	RR	2	4.83	294	74	33
WD	IH	RR	3	6.75	97	24	11
WD	IH	HL	3	12.00	42	10	5
WD	IH	BP	3	4.00	158	40	18
WD	IH	SP	1	12.21	65	16	7
WD	IH	SP	2	8.68	104	26	12
WD	IH	SP	3	12.20	47	12	5
WE/H	ER	RR	1	6.00	94	24	10
WE/H	ER	RR	3	6.38	27	7	3
WE/H	ER	RR	4	4.75	142	35	16
WE/H	ER	HL	1	6.00	117	29	13
WE/H	ER	HL	3	8.40	42	10	5
WE/H	ER	BP	3	5.83	65	26	7
WE/H	ER	RG	1	19.60	15	4	2
WE/H	ER	RG	3	18.73	10	2	1
WE/H	ER	RG	4	15.67	21	5	2
WE/H	ER	SP	1	5.71	40	10	4
WE/H	ER	SP	2	19.20	55	14	6
WE/H	ER	SP	3	10.44	20	5	2
WE/H	ER	SP	4	7.00	37	9	4
WE/H	OH	RR	1	14.83	10	3	1
WE/H	OH	RR	2	11.71	18	5	2
WE/H	OH	RR	3	17.52	14	4	2
WE/H	OH	RR	4	10.29	99	25	11
WE/H	OH	HL	1	7.29	29	7	3
WE/H	OH	HL	3	12.15	17	4	2
WE/H	OH	HL	4	7.12	35	9	4
WE/H	OH	BP	1	14.50	12	3	1
WE/H	OH	BP	3	7.00	36	9	4
WE/H	OH	BP	4	3.50	145	36	16
WE/H	OH	RG	1	10.17	76	19	8
WE/H	OH	RG	2	8.25	88	22	10
WE/H	OH	RG	3	15.63	28	7	3
WE/H	OH	RG	4	8.12	26	7	3
WE/H	OH	SP	1	9.50	295	74	33
WE/H	OH	SP	3	10.58	19	5	2

Table 6.--Number of days required to estimate mean daily shoreline participation during the night on American Samoa from the 10, 20, and 30% CV levels during 1991-93. Negative binomial model was used to estimate variance of the means. ER = exposed reef, IH = inner harbor, OH = outer harbor, RR = rod and reel, RG = reef gleaning, BP = bamboo pole, HL = handline, and SP = spearfishing.

Type day	Habitat	Method	Qtr	Daily mean	CV level 10%	CV level 20%	CV level 30%
WD	ER	RR	1	9.25	76	19	8
WD	ER	RR	2	11.00	23	6	3
WD	ER	RR	3	7.00	52	13	6
WD	ER	RR	4	7.75	27	7	3
WD	ER	RG	1	14.25	32	8	4
WD	ER	RG	3	10.29	146	36	16
WD	ER	RG	4	10.80	19	5	2
WD	ER	SP	1	11.80	25	6	3
WD	ER	SP	3	8.56	45	11	5
WD	ER	SP	4	3.00	54	13	6
WD	OH	RR	1	26.12	7	2	1
WD	OH	RR	2	47.35	3	1	1
WD	OH	RR	3	36.70	107	27	12
WD	OH	RR	4	13.00	13	3	1
WD	OH	HL	1	34.25	5	1	1
WD	OH	HL	2	168.19	1	1	1
WD	OH	HL	3	122.04	17	4	2
WD	OH	HL	4	15.11	11	3	1
WD	OH	BP	3	13.23	11	3	1
WD	OH	BP	4	12.00	30	7	3
WD	OH	RG	1	20.00	100	25	11
WD	OH	RG	3	23.13	6	2	1
WD	OH	RG	4	11.00	21	5	2
WD	OH	SP	1	17.89	14	3	2
WD	OH	SP	2	14.40	76	19	8
WD	OH	SP	3	15.91	17	4	2
WD	OH	SP	4	9.25	269	67	30
WD	IH	HL	3	16.00	11	3	1
WE/H	ER	RR	1	14.00	15	4	2
WE/H	ER	RR	3	8.00	51	13	6
WE/H	ER	RR	4	6.67	41	10	5
WE/H	ER	RG	1	28.00	6	1	1
WE/H	ER	RG	4	18.00	18	5	2
WE/H	ER	SP	1	12.50	27	7	2
WE/H	ER	SP	4	8.29	58	15	6

Table 6.--Continued.

Type day	Habitat	Method	Qtr	Daily mean	CV level 10%	CV level 20%	CV level 30%
WE/H	OH	RR	1	15.43	21	5	2
WE/H	OH	RR	2	106.00	2	1	2
WE/H	OH	RR	3	39.39	4	1	1
WE/H	OH	RR	4	14.14	19	5	2
WE/H	OH	HL	1	21.50	11	3	1
WE/H	OH	HL	3	163.67	1	1	1
WE/H	OH	HL	4	22.75	8	2	1
WE/H	OH	BP	3	18.00	16	4	2
WE/H	OH	BP	4	13.33	23	6	3
WE/H	OH	RG	1	12.67	39	10	4
WE/H	OH	RG	4	17.00	24	6	3
WE/H	OH	SP	1	9.20	24	6	3
WE/H	OH	SP	2	39.00	8	2	1
WE/H	OH	SP	4	13.71	22	5	2

Table 7.--Number of days required to estimate mean daily shoreline rod and reel catch rates in kg/hr (lb/hr) on American Samoa at the 10, 20, and 30% CV levels during 1991-93. The estimates were partitioned by quarters and limited to the outer harbor area only.

Quarter	kg/hr	(lb/hr)	CV level		
			10%	20%	30%
1	5.32	(11.73)	2	1	1
2	3.64	(8.02)	8	2	1
3	1.15	(2.54)	6	2	1
4	0.58	(1.29)	*	*	*

*Inconclusive

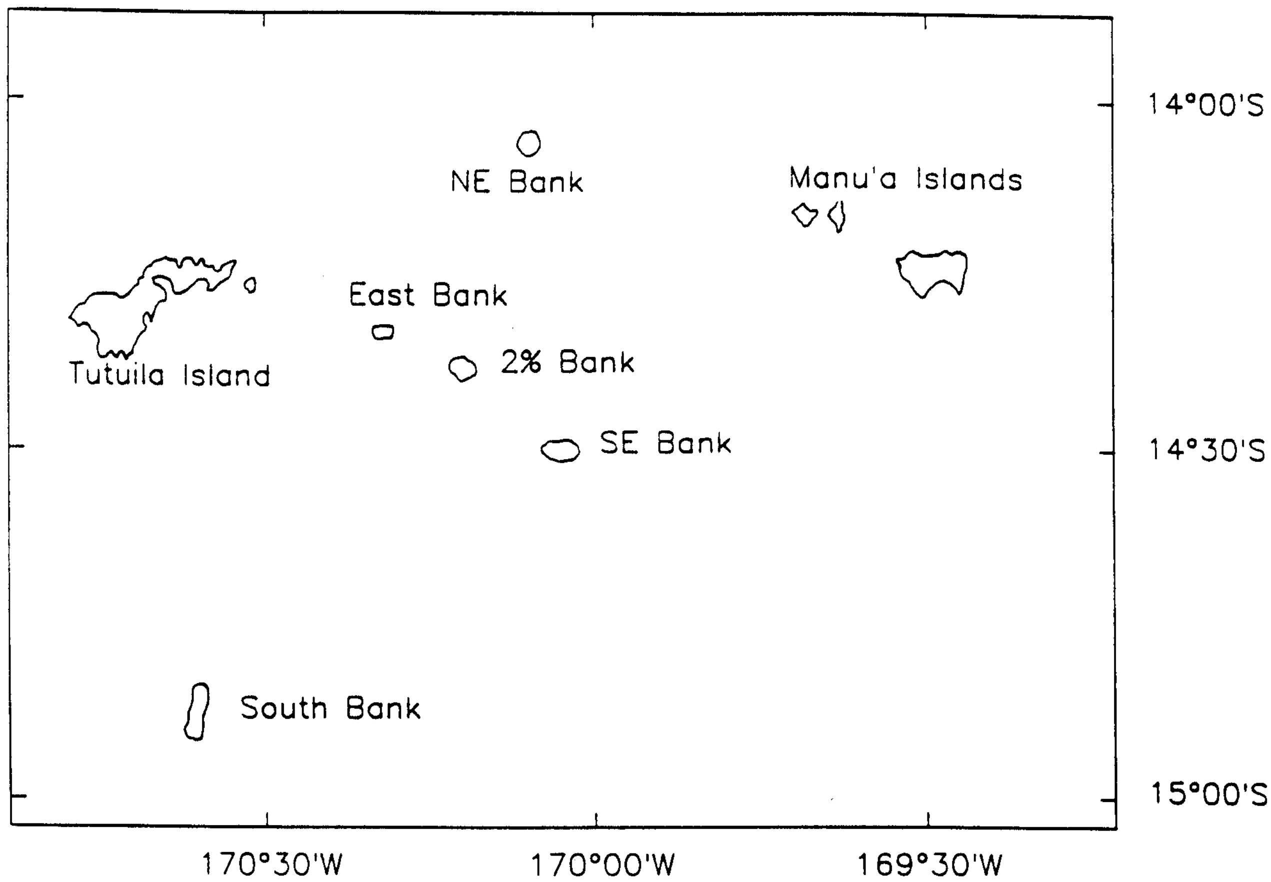


Figure 2.--Map of American Samoa and the surrounding offshore banks.

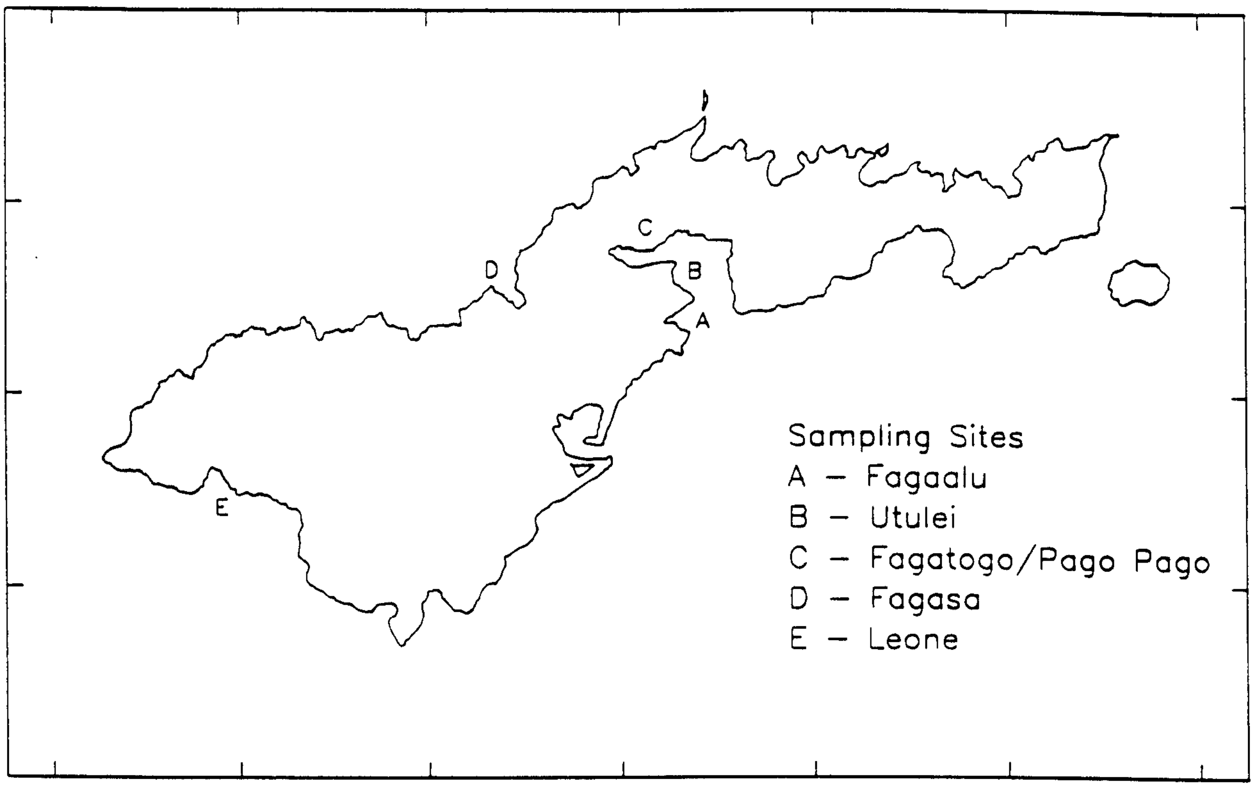


Figure 3.--Map of the island of Tutuila, American Samoa and the five major boat launching sites.

DEPARTMENT OF MARINE AND WILDLIFE RESOURCES

OFFSHORE SURVEY

INTERVIEWER:________________ **INTERVIEW TIME:**________________

DATE:________________ (MM/DD/YY) **TYPE DAY: WD 1 WE/H 2**

BOAT OWNER:________________ **NUMBER OF FISHERS:**________

----------------**CATCH/EFFORT DATA FOR ONE METHOD ONLY**----------------

METHOD:________________ **HOURS FISHED:**________ **TOTAL CATCH:**________

Troll = 2
Bottom = 4
Troll/Bottom = 5
Spear/Dive = 6
Atule = 8
Longline = 16
Other = write-in

NUMBER OF LINES USED:________

AREA FISHED:________

HOME ISLAND:________

SPECIES NAME	SPECIES WEIGHT	NUM PCS	DISPOSITION	$/LB	WT	LEN	WT	LEN

Figure 4.--Department of Marine and Wildlife Resources offshores survey data collection form.

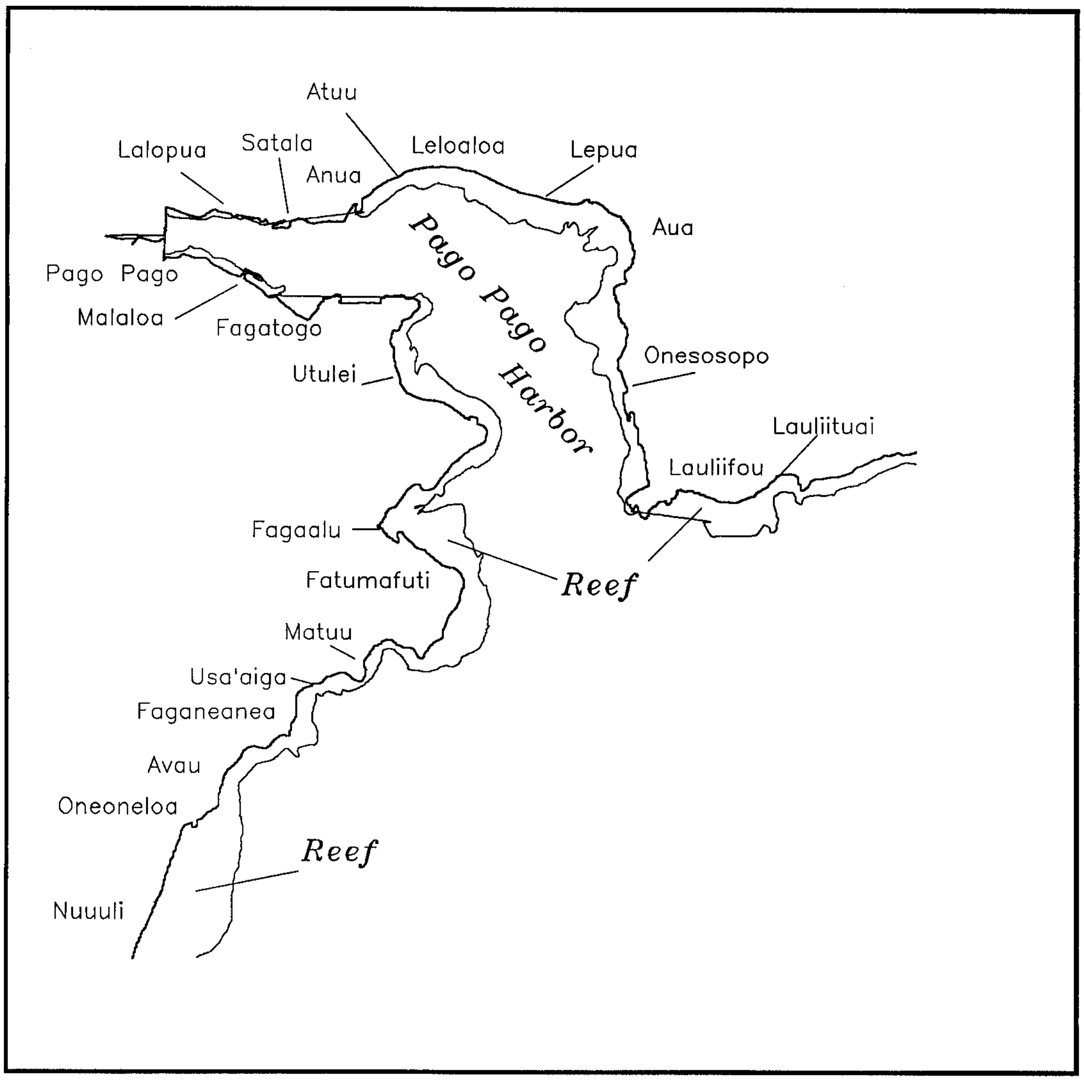


Figure 5.--Map of shoreline study site including 22 villages and encompassing Pago Pago Harbor on the island of Tutuila, American Samoa.

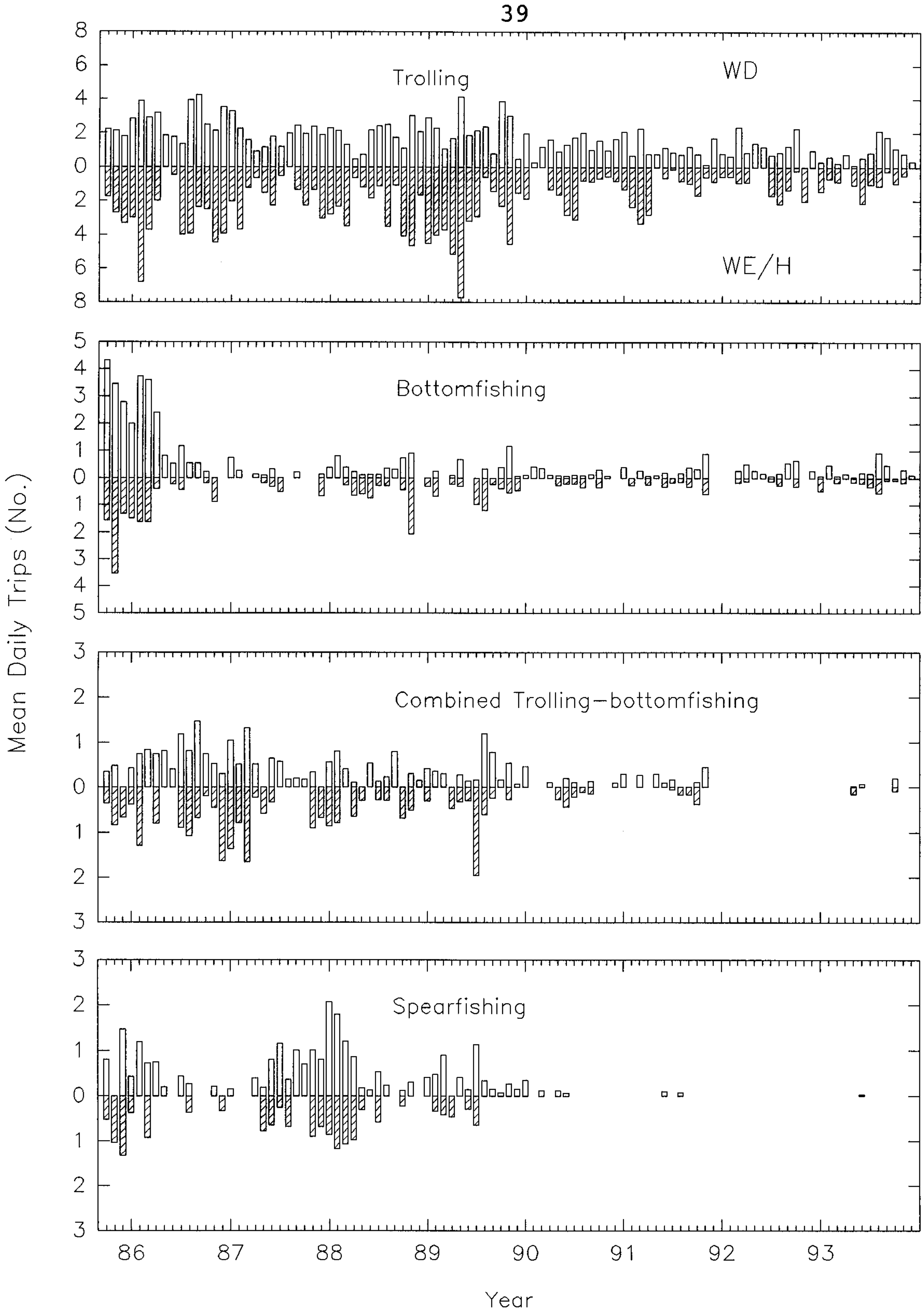


Figure 6.--Monthly averages of daily trips by the major fishing activities from 1985-93.

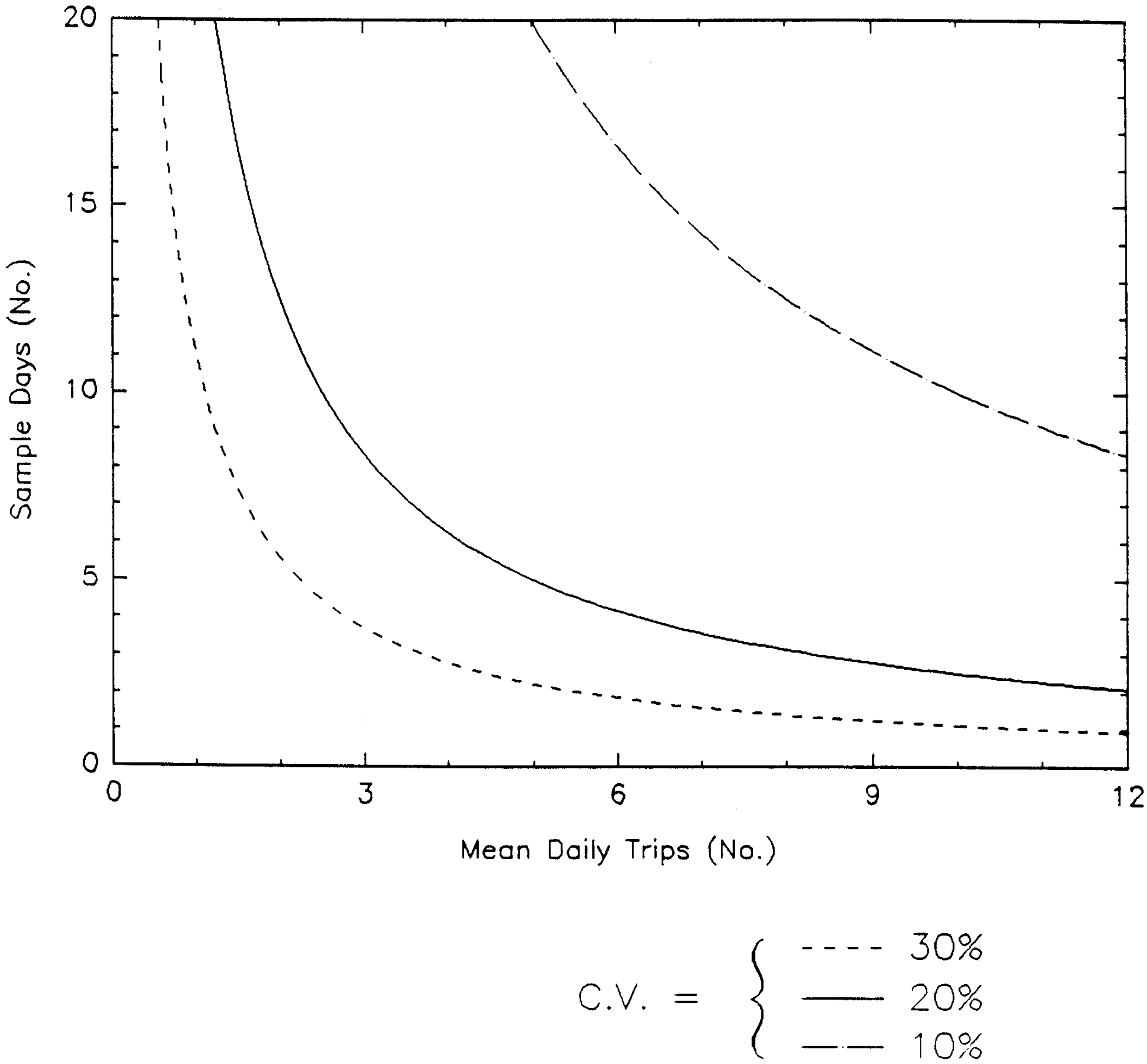


Figure 7.--Required sample size for estimating mean daily fishing activity around American Samoa at the 10, 20, and 30% CV levels for both WD and WE/H.

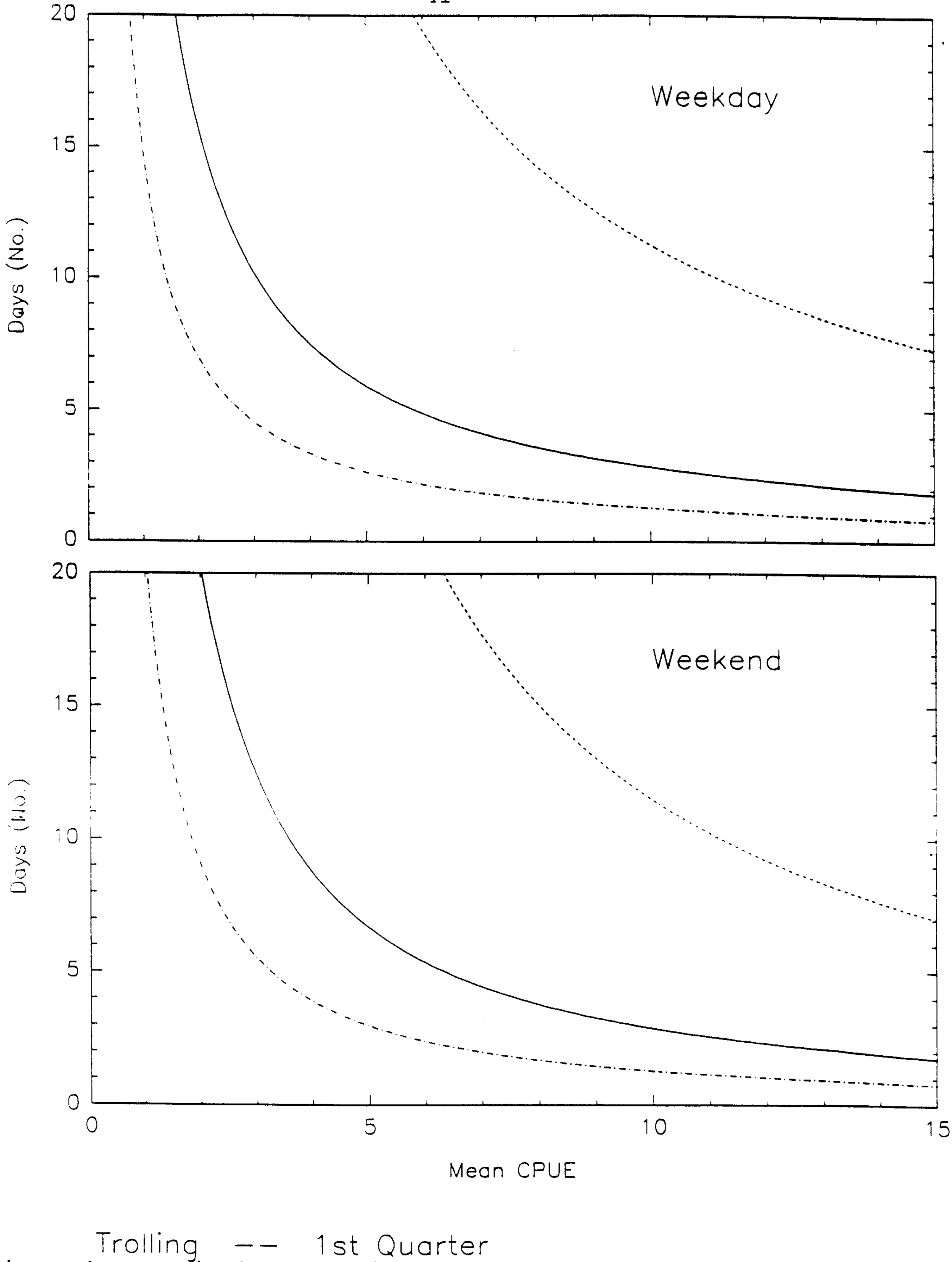


Figure 8.--Required sample size for estimating first quarter mean daily trolling CPUE at the 10, 20, and 30% CV levels for both WD and WE/H with a ratio estimator.

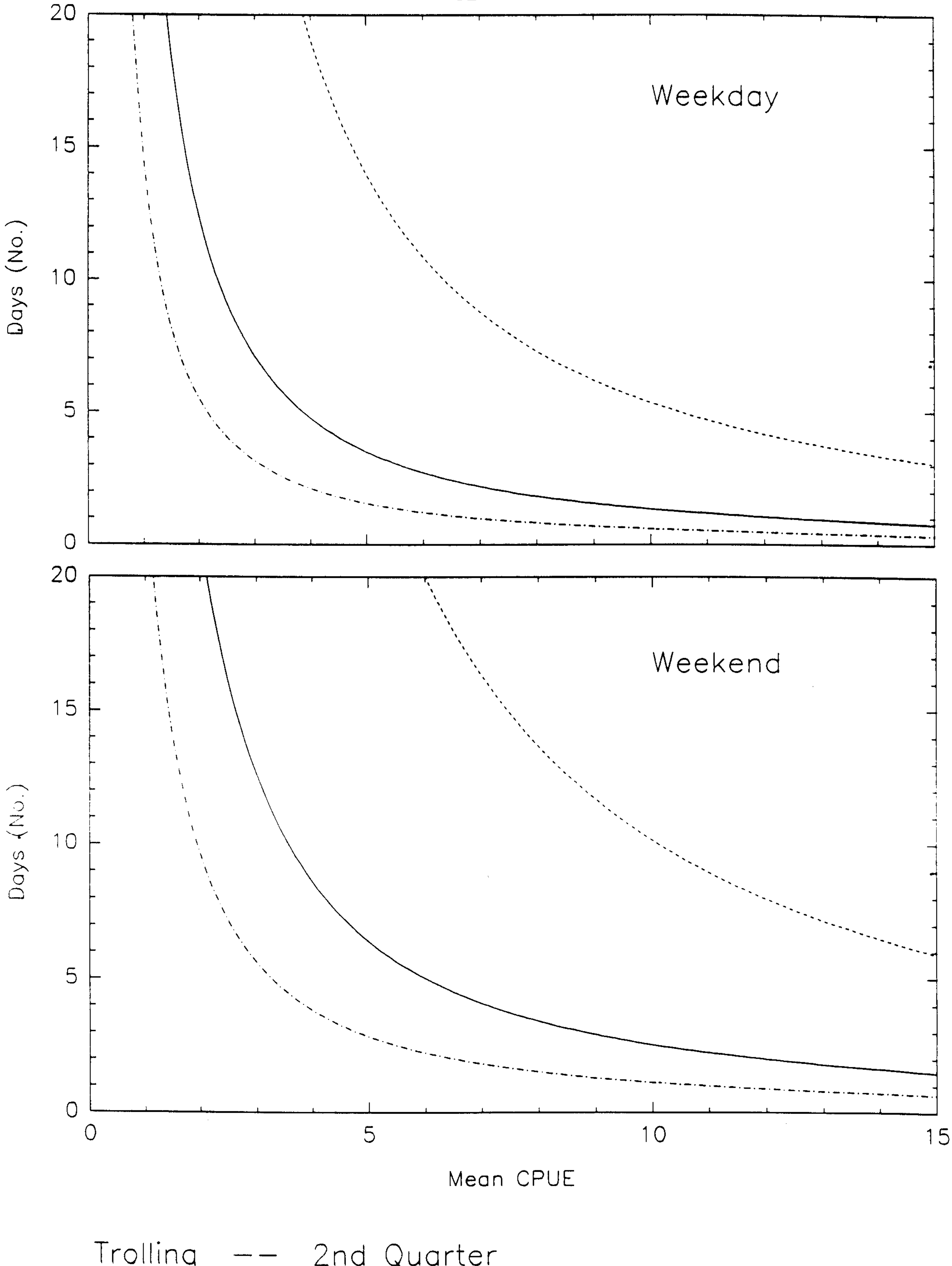
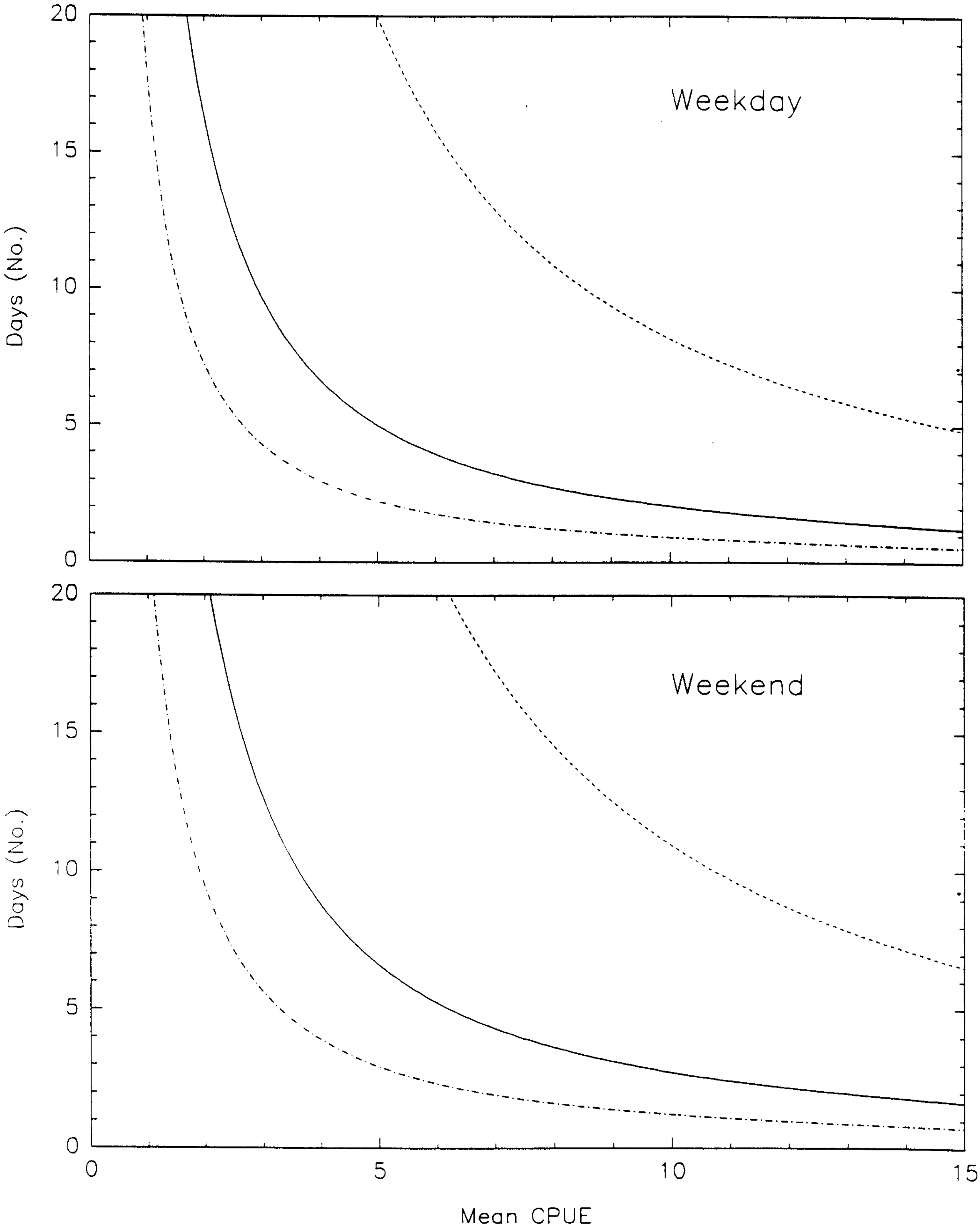
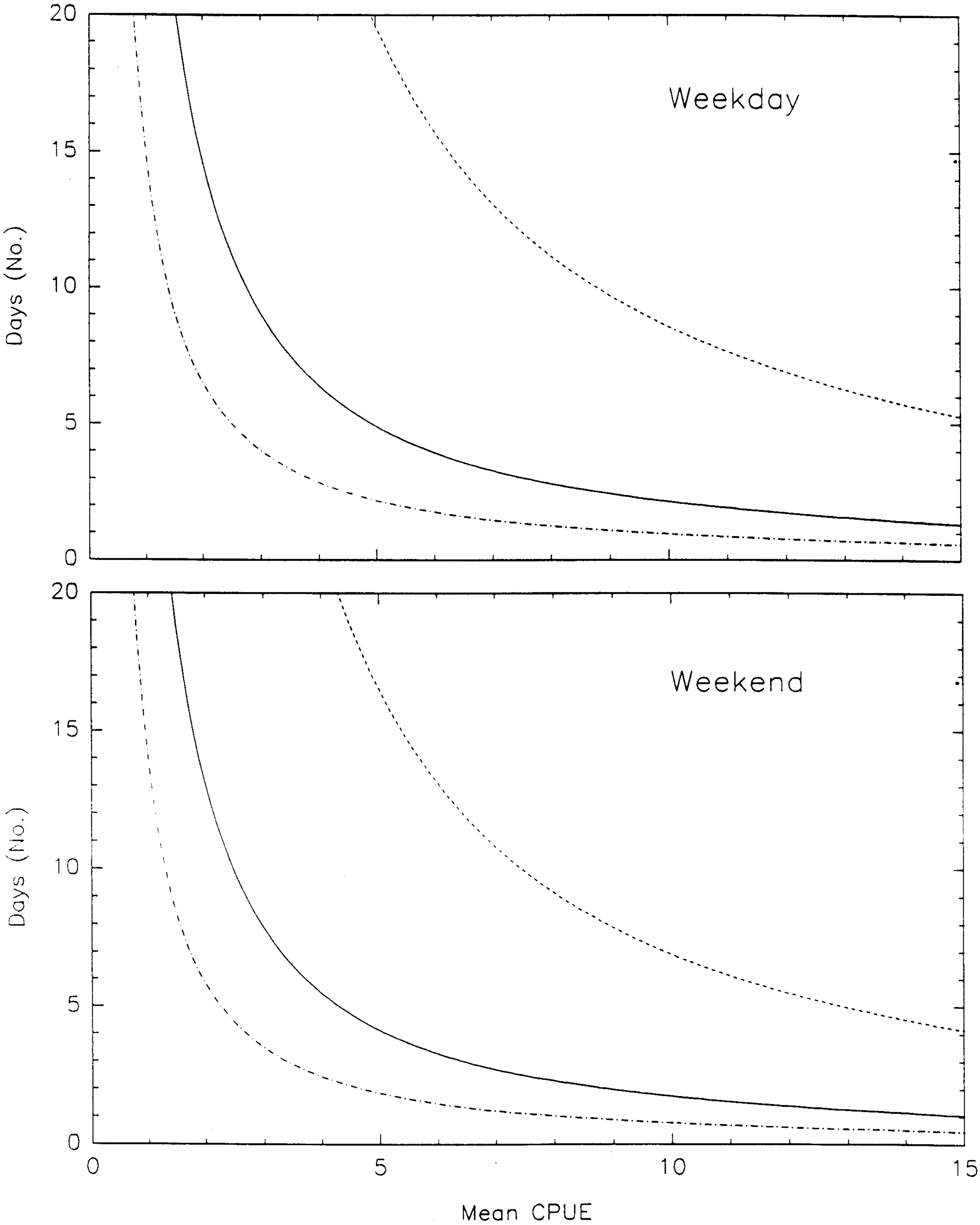


Figure 9.--Required sample size for estimating second quarter mean daily trolling CPUE at the 10, 20, and 30% CV levels for both WD and WE/H with a ratio estimator.



Trolling -- 3rd Quarter

Figure 10.--Required sample size for estimating third quarter mean daily trolling CPUE at the 10, 20, and 30% CV levels for both WD and WE/H with a ratio estimator.



Trolling -- 4th Quarter

Figure 11.--Required sample size for estimating fourth quarter mean daily trolling CPUE at the 10, 20, and 30% CV levels for both WD and WE/H with a ratio estimator.

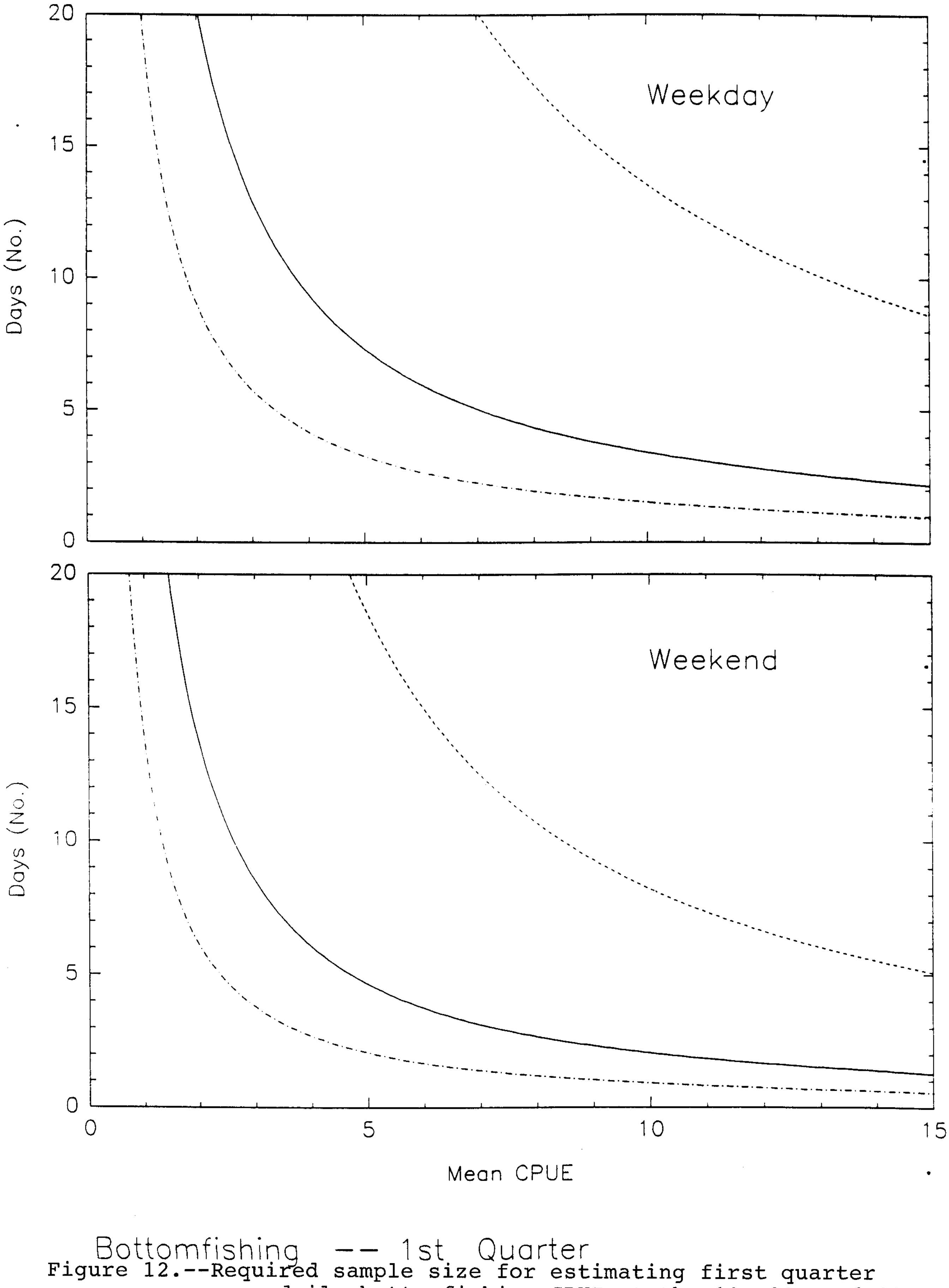


Figure 12.--Required sample size for estimating first quarter mean daily bottomfishing CPUE at the 10, 20, and 30% CV levels for both WD and WE/H with a ratio estimator.

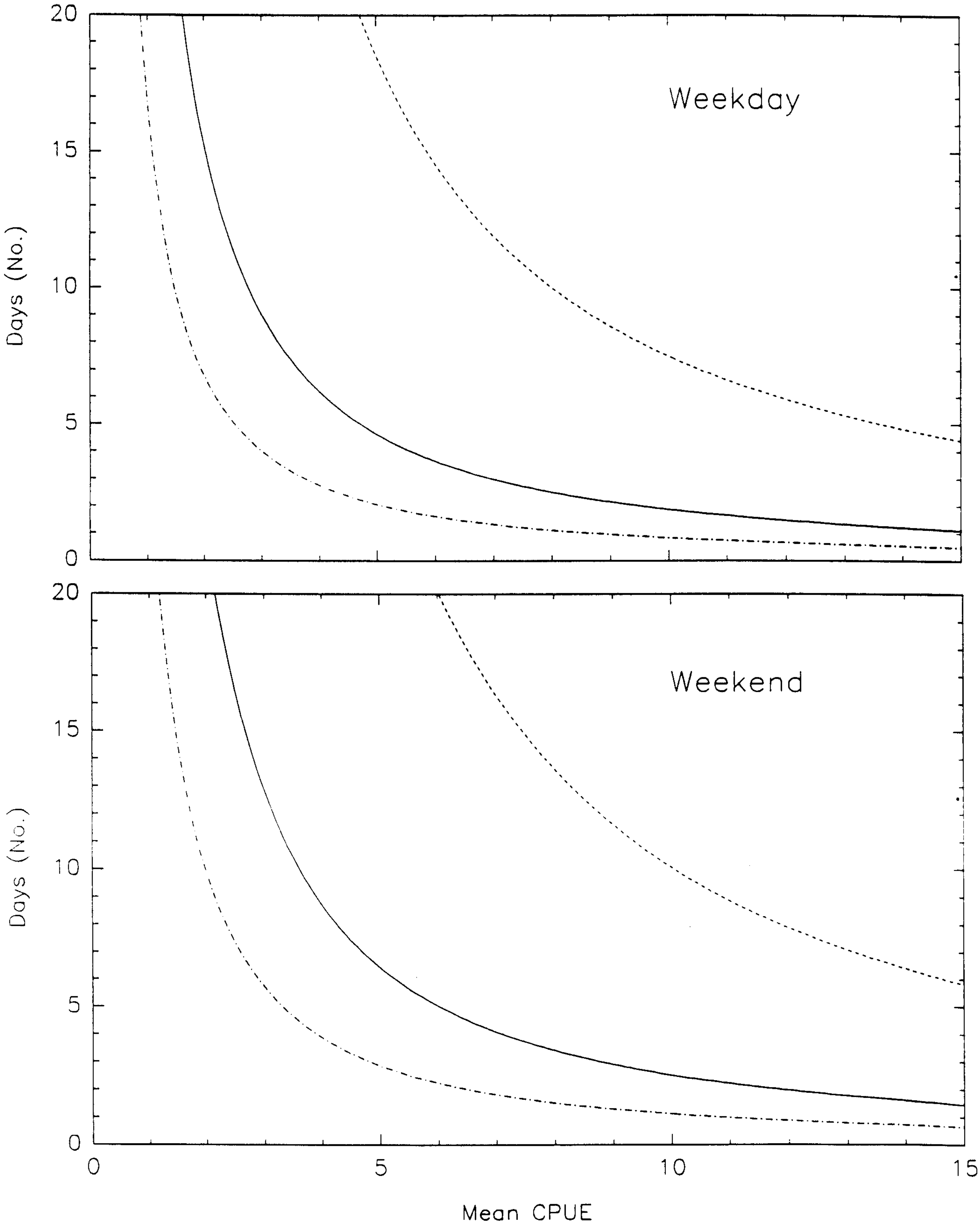


Figure 13.--Required sample size for estimating second quarter mean daily bottomfishing CPUE at the 10, 20, and 30% CV levels for both WD and WE/H with a ratio estimator.

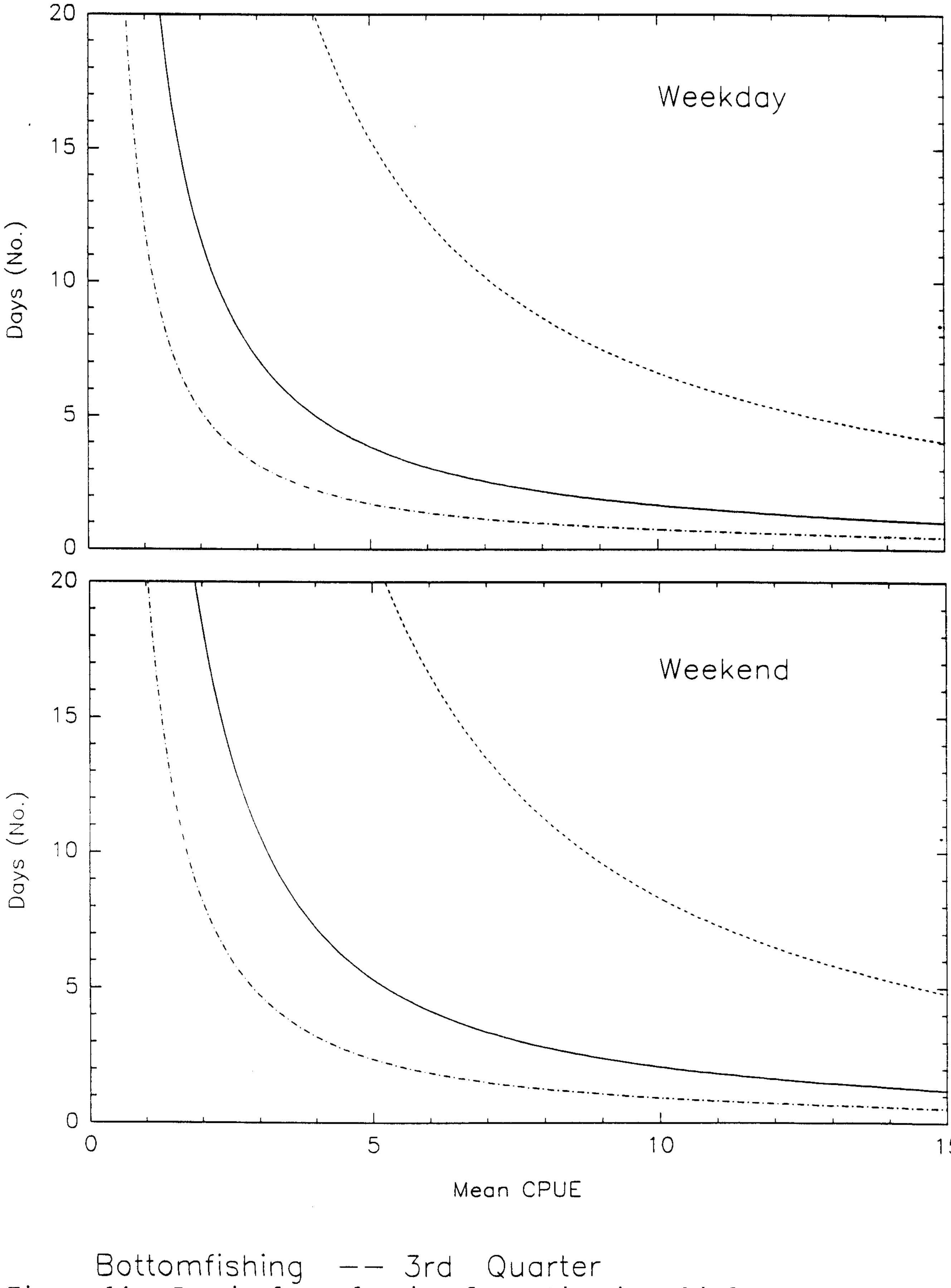


Figure 14.--Required sample size for estimating third quarter mean daily bottomfishing CPUE at the 10, 20, and 30% CV levels for both WD and WE/H with a ratio estimator.

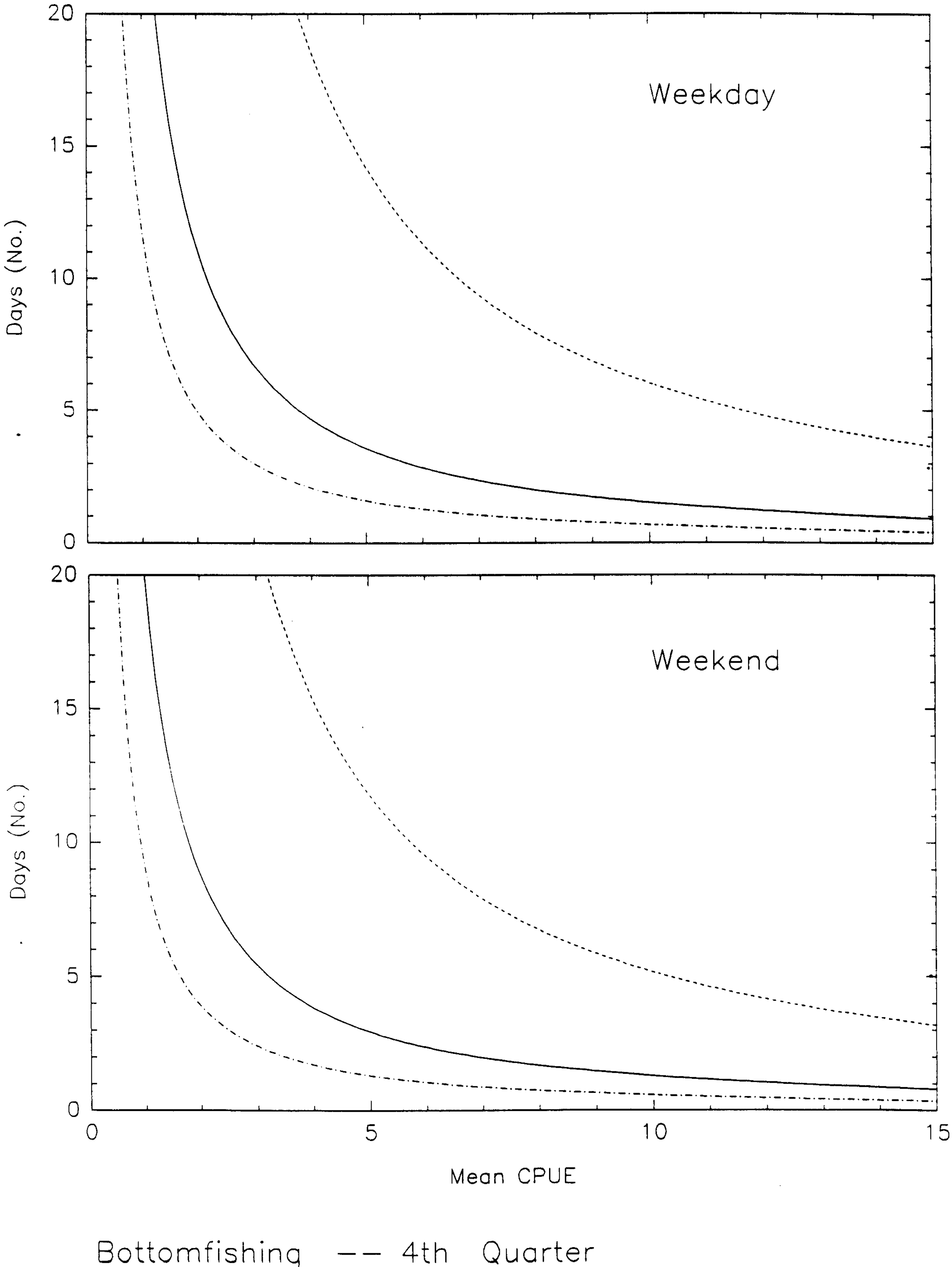
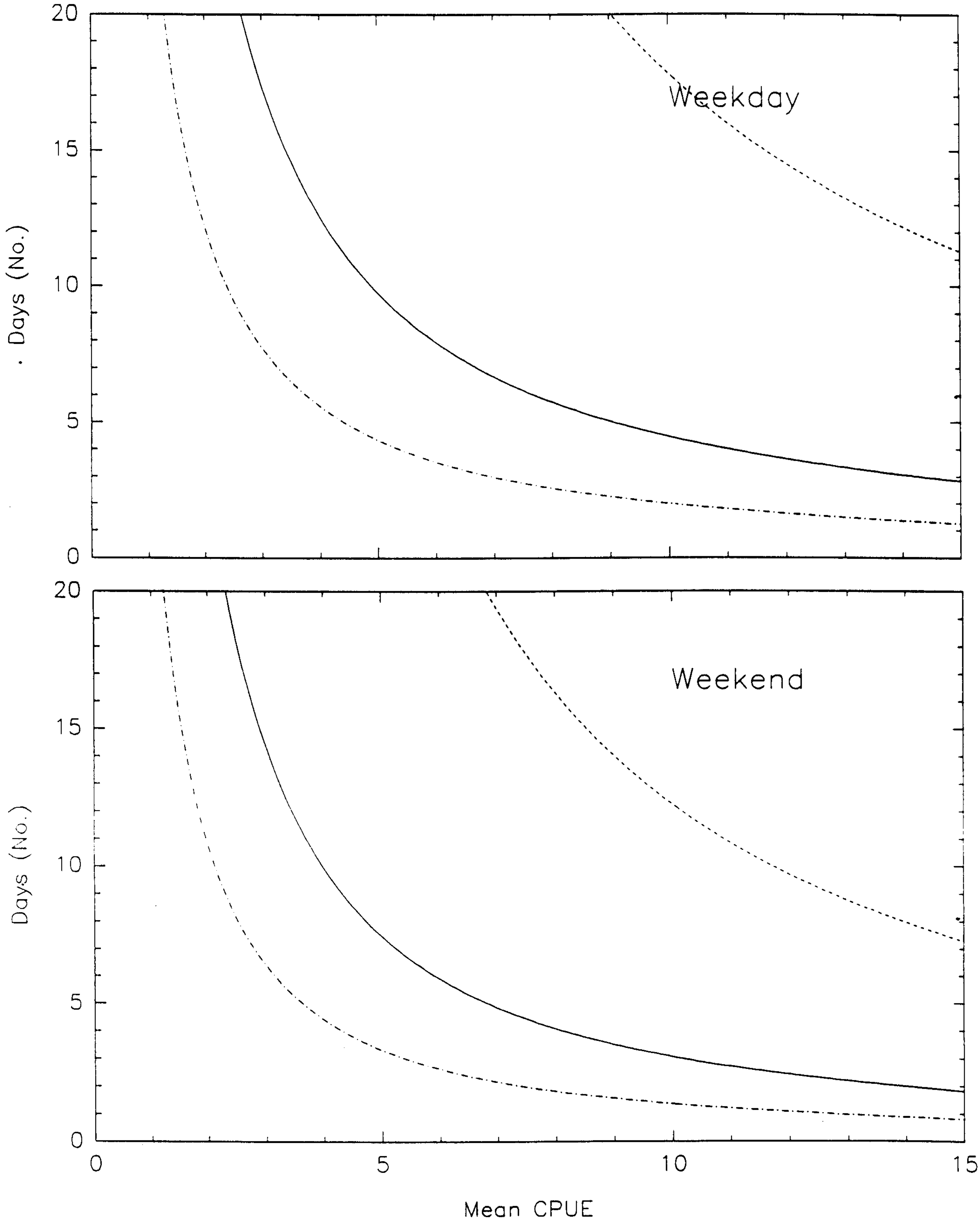
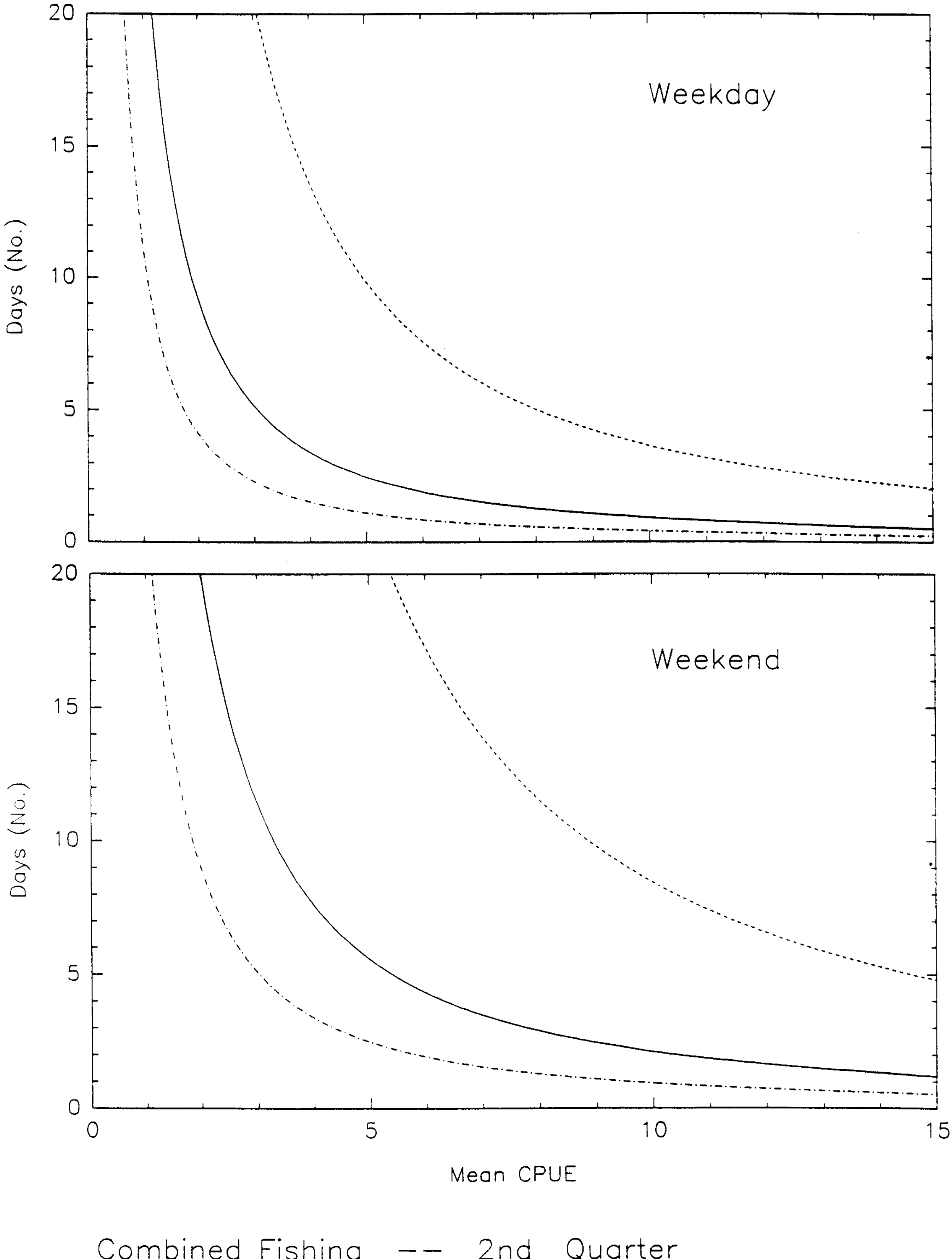


Figure 15.--Required sample size for estimating fourth quarter mean daily bottomfishing CPUE at the 10, 20, and 30% CV levels for both WD and WE/H with a ratio estimator.

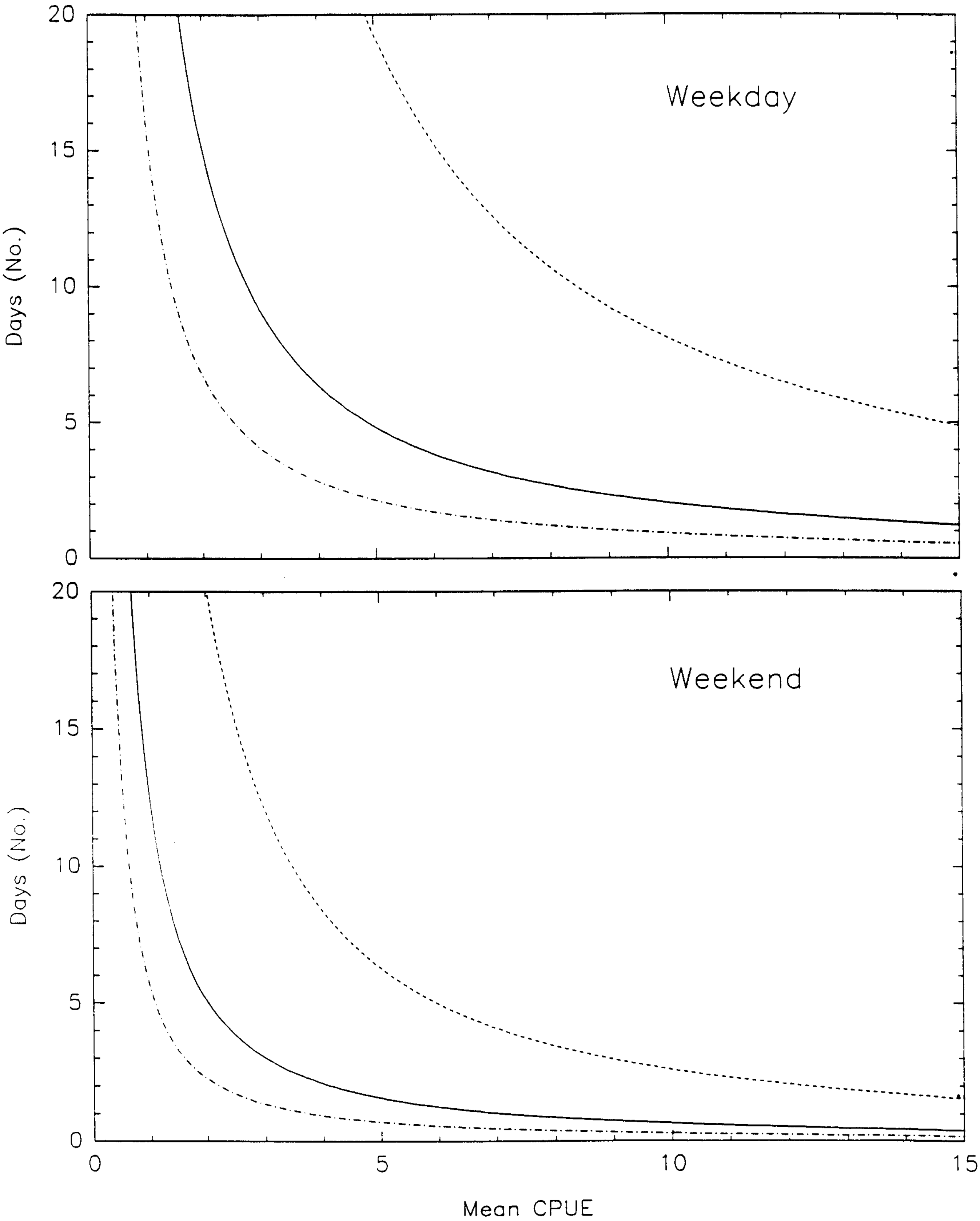


Combined Fishing -- 1st Quarter

Figure 16.--Required sample size for estimating first quarter mean daily combined trolling and bottomfishing CPUE at the 10, 20, and 30% CV levels for both WD and WE/H with a ratio estimator.

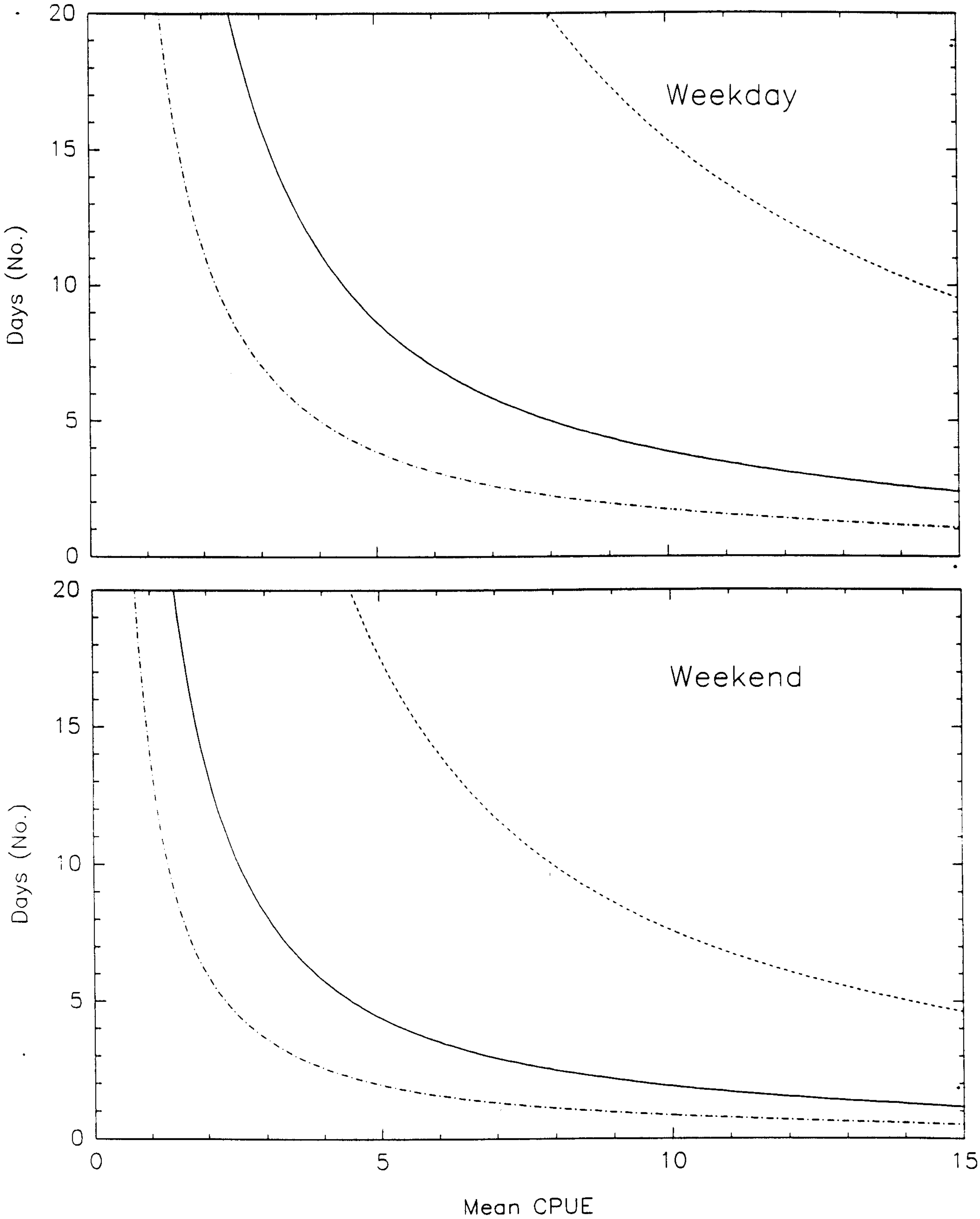


Combined Fishing -- 2nd Quarter
Figure 18.--Required sample size for estimating third quarter mean daily combined trolling and bottomfishing CPUE at the 10, 20, and 30% CV levels for both WD and WE/H with a ratio estimator.



Combined Fishing -- 3rd Quarter

Figure 18.--Required sample size for estimating third quarter mean daily combined trolling and bottomfishing CPUE at the 10, 20, and 30% CV levels for both WD and WE/H with a ratio estimator.



Combined Fishing -- 4th Quarter

Figure 19.--Required sample size for estimating fourth quarter mean daily combined trolling and bottomfishing CPUE at the 10, 20, and 30% CV levels for both WD and WE/H with a ratio estimator.

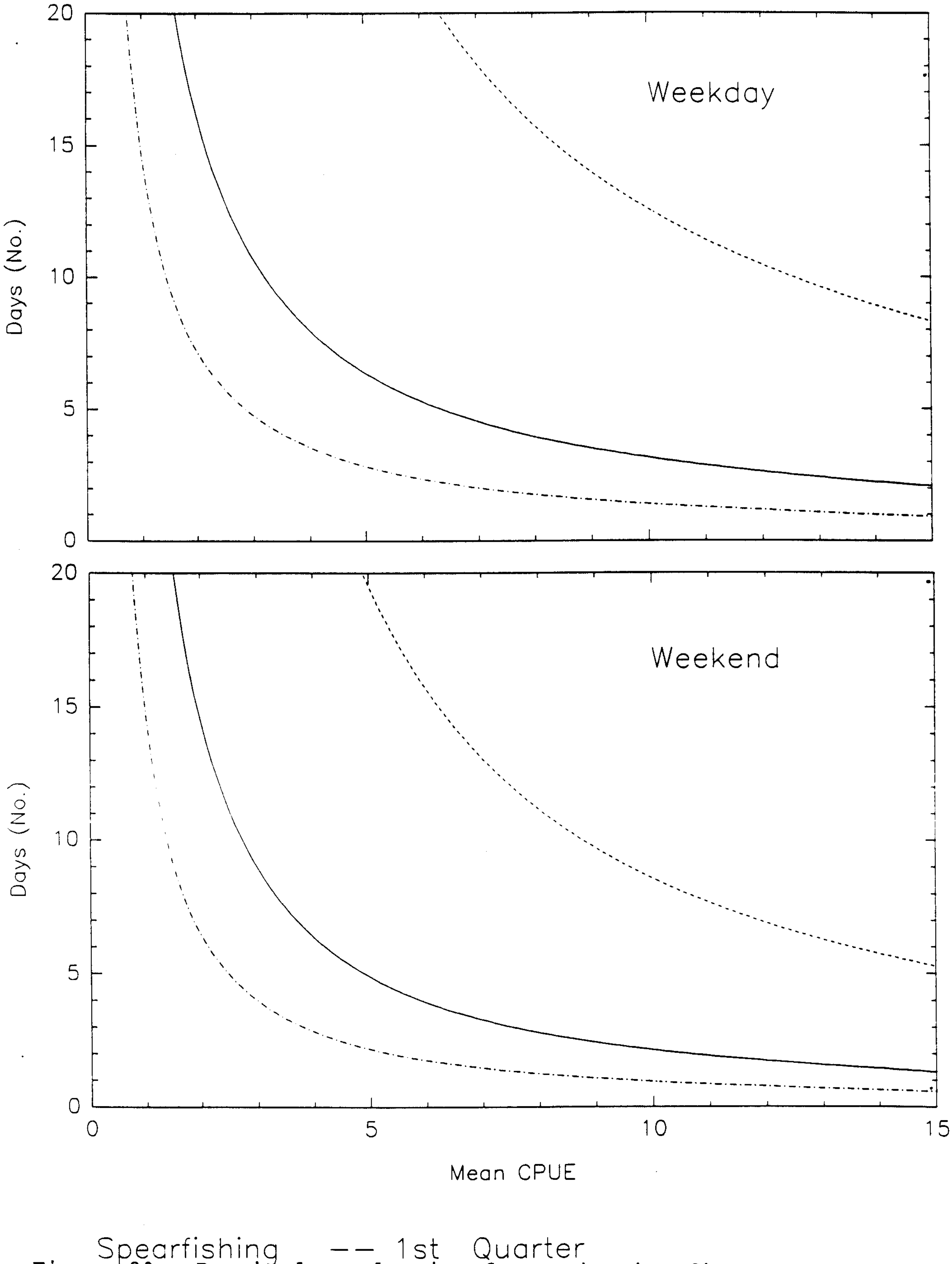


Figure 20.--Required sample size for estimating first quarter mean daily spearfishing CPUE at the 10, 20, and 30% CV levels for both WD and WE/H with a ratio estimator.

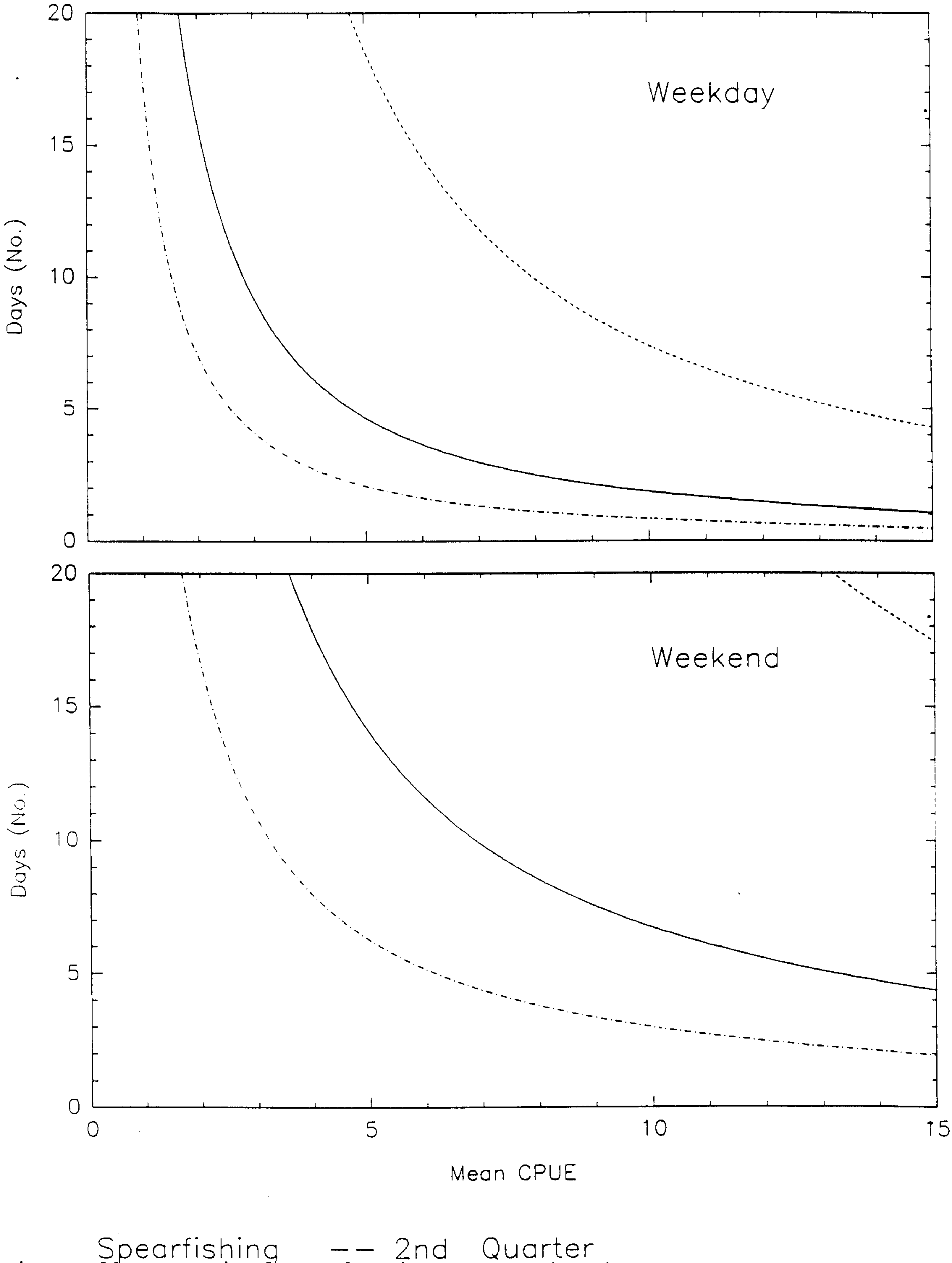


Figure 21.--Required sample size for estimating second quarter mean daily spearfishing CPUE at the 10, 20, and 30% CV levels for both WD and WE/H with a ratio estimator.

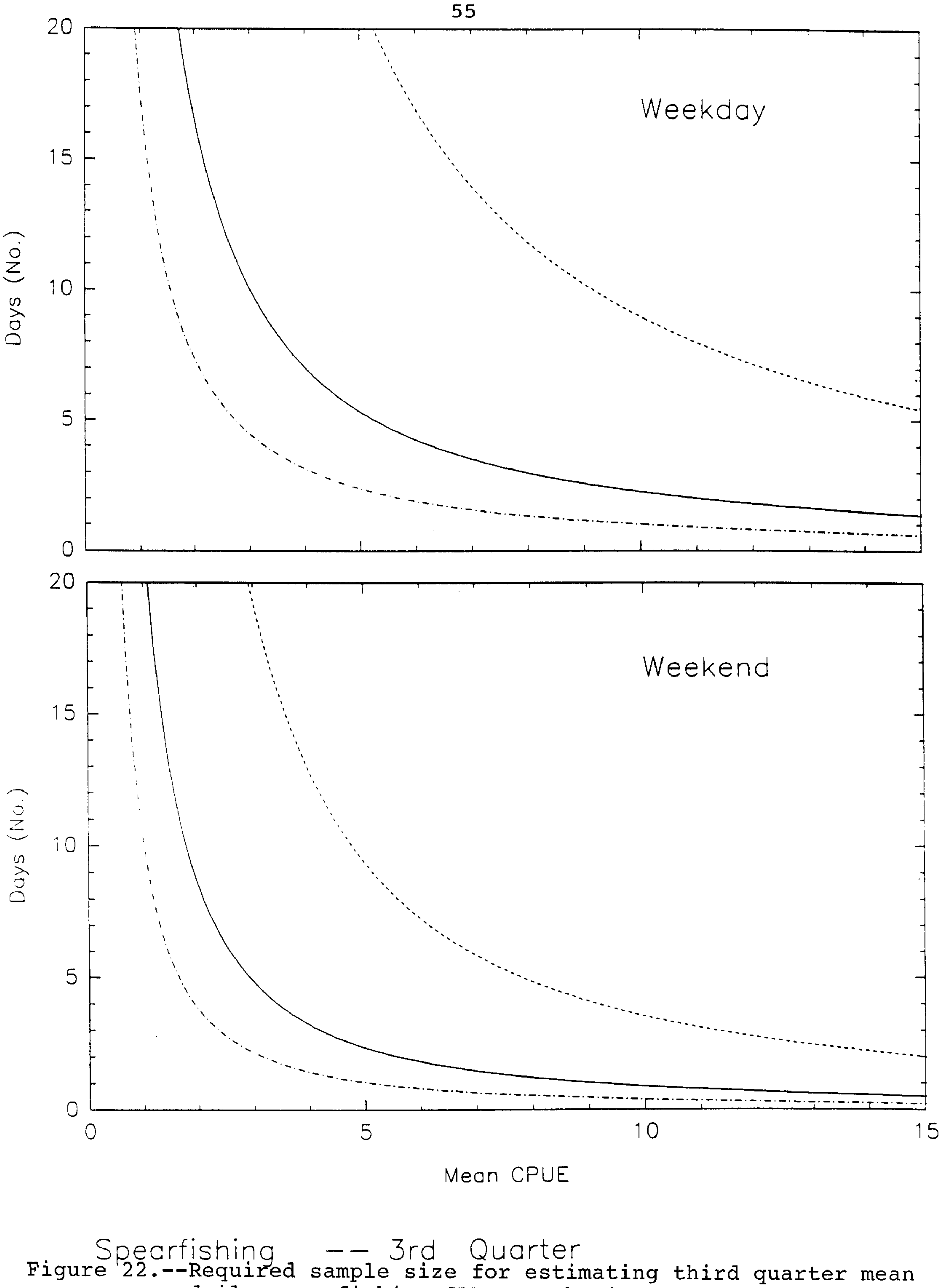
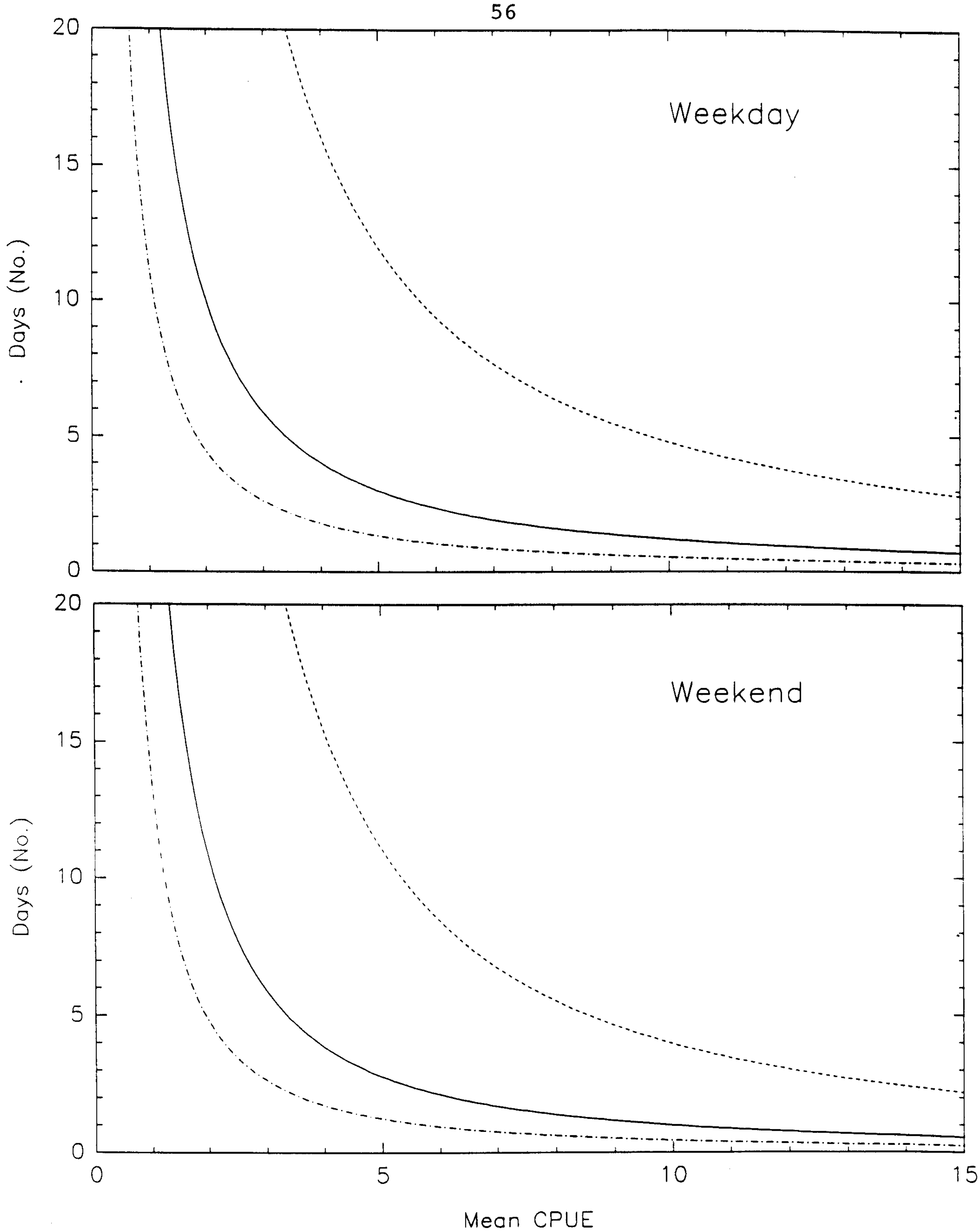


Figure 22.--Required sample size for estimating third quarter mean daily spearfishing CPUE at the 10, 20, and 30% CV levels for both WD and WE/H with a ratio estimator.



Spearfishing -- 4th Quarter

Figure 23.--Required sample size for estimating fourth quarter mean daily spearfishing CPUE at the 10, 20, and 30% CV levels for both WD and WE/H with a ratio estimator.